Variability in Size and Age at Sexual Maturity of American Plaice and Yellowtail Flounder in the Canadian Maritimes Region of the Northwest Atlantic Ocean

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VARIABILITY IN SIZE AND AGE AT SEXUAL MATURITY OF AMERICAN PLAICE AND YELLOWTAIL FLOUNDER IN THE CANADIAN MARITIMES REGION OF THE NORTHWEST ATLANTIC OCEAN

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ABSTRACT

Beacham, T. D. 1983. Variability in size and age at sexual maturity of American plaice and yellowtail flounder in the Canadian Maritimes region of the Northwest Atlantic Ocean. Can. Tech. Rep. Fish. Aquat. Sci. 1196: iv + 75 p.

The variability in length and age at which 50% of individuals were mature was investigated for American plaice (Hippoglossoides platessoides) and yellowtail flounder (Limanda ferruginea) in the Northwest Atlantic. Median length and age at maturity for plaice and yellowtail flounder generally declined through time, with the decline greater in females than in males. Males matured at smaller sizes and younger ages than did females. During 1959-1964, median length at maturity for female American plaice ranged from 31.6 cm in NAFO Div. 4X to 40.8 cm in Div. 4T, while median age at maturity ranged from 9.5 yr in Div. 4T to 11.5 yr in Div. 4W. During 1975-1979, median length at maturity for female American plaice ranged from 27.0 cm in Div. 4T to 30.8 cm in Div. 4X, while median age at maturity ranged from 4.7 yr in Div. 4X to 6.7 yr in Subdiv. 4Vn. American plaice and yellowtail flounder in warmer waters generally matured at younger ages than did those in colder waters.

For yellowtail flounder during 1975 to 1979, median length at maturity for males ranged from 20.1 cm in NAFO Div. 4X to 24.4 cm in Subdiv. 4Vs, while median age at maturity ranged from 2.0 to 4.0 yr, respectively. Median length (and age) at maturity for females ranged from 23.4 cm (4.3 yr) in Div. 4T to 29.4 cm (2.9 yr) in Div. 4X.

Key words: age, American plaice, length, maturity, population dynamics, Scotian Shelf, yellowtail flounder.

RÉSUMÉ

Beacham, T. D. 1983. Variability in size and age at sexual maturity of American plaice and yellowtail flounder in the Canadian Maritimes region of the Northwest Atlantic Ocean. Can. Tech. Rep. Fish. Aquat. Sci. 1196: iv + 75 p.

L'auteur a étudié la variabilité de la longueur et de l'âge à lequel 50 % des individus sont matures chez la plie canadienne (Hippoglossoides platessoides) et la limande à queue jaune (Limanda ferruginea) peuplant l'Atlantique nord-ouest. La longueur et l'âge médians à maturité de ces deux espèces diminuent généralment en fonction du temps, cette baisse étant plus prononcée chez les femelles. Les mâles atteignent la maturité à une plus petite taille et à un plus juene âge que les femelles. De 1959 à 1964, la longueur et l'âge médians à maturité des plies canadiennes femelles variaient respectivement de 31,6 cm dans la division 4X de l'OPANO à 40,8 cm dans la division 4T et de 9,5 ans dans 4T à 11,5 ans dans 4W. De 1975 à 1979, ces caractéristiques variaient de 27,0 cm dans 4T à 30,8 cm dans 4X et de 4,7 ans dans 4X à 6,7 ans dans la sous-division 4Vn. La plie canadienne et la limande à queue jaune vivant dans les eaux chaudes atteignent la maturité à un plus juene âge que celles des eaux froides.

De 1975 à 1979, dans la division 4X et la sous-division 4Vs, la longueur et l'âge médians des limandes à queue jaune mâles variaient de 20,1 à 24,4 cm et de 2,0 à 4,0 ans respectivement. Chez les femelles, ces caractéristiques dans 4T et 4X variaient de 23,4 à 29,4 cm et de 4,3 ans à 2,9 ans.

Mots-clés: âge, plie canadienne, longueur, maturité, dynamique de population, plate-forme Scotian, limande à queue jaune.

INTRODUCTION

Canadian groundfish surveys have indicated that American plaice (Hippoglossoides platessoides) is abundant in the southern Gulf of St. Lawrence (NAFO Div. 4T) (Fig. 1), and widespread on the Scotian Shelf, being most abundant in Div. 4V (Scott 1976). Powles (1965) outlined stock structure of American plaice in Div. 4T, but stock boundaries remain uncertain for plaice on the Scotian Shelf. The majority of the Canadian catch of American plaice in NAFO Subarea 4 is derived from Divs. 4T and 4V, with the fishery conducted largely by otter trawlers, although in Div. 4T Danish and Scottish seiners contribute significantly to the catch. Yellowtail flounder (Limanda ferruginea) is most abundant in waters less than 50 fathoms (Scott 1976), with Pitt (1970) reporting a similar result for yellowtail flounder in the Newfoundland area. The bulk of the Canadian catches in the yellowtail flounder fishery in NAFO Subarea 4 is derived on the northern Scotian Shelf from Divs. 4V and 4W. Although yellowtail is present in the southern Gulf of St. Lawrence (Div. 4T), it is not caught in any significant amount.

Vertebrate population dynamics are determined by the combined effects of reproduction, growth, dispersal, and mortality. The age at which individuals attain sexual maturity has a large impact upon the potential for population growth rates (Cole 1954; Stearns 1976). Growth rates of individuals and reproductive potential of a population are linked by the size and age at which individuals attain sexual maturity, and therefore these parameters are of importance in an investigation of population dynamics. The presence of American plaice and yellowtail flounder in several areas of NAFO Subarea 4 presented an opportunity for an investigation of variability in median size and age at sexual maturity among areas. The major purpose of this paper is the present historical changes in median size and age at maturity and to attempt to account for some of this variability between the species in different areas.

MATERIALS AND METHODS

The data analyzed in the present paper were derived from Canadian groundfish surveys of the M/V HARENGUS, E.E. PRINCE, and A.T. CAMERON from 1959-1979. Annual values for median (50% mature point) length and age at maturity were calculated if possible. These values were calculated from data obtained during July surveys on the Scotian Shelf and September surveys in the southern Gulf of St. Lawrence. Maturity ogives based on length or age were also calculated if possible for four periods: 1959-1964, 1965-1969, 1970-1974, and 1975-1979. However, yellowtail from the 1979 samples had not been aged at the time of the analysis. All surveys conducted in each interval were included in the analysis. Details of the gear used by the CAMERON and HARENGUS were given by Jean (1964). Briefly summarized, groundfish surveys on the HARENGUS were conducted with a #35 Yankee otter trawl, those on the PRINCE with a #36 Yankee otter trawl and those on CAMERON before 1970 with a #41 A

Western otter trawl, and subsequently with a #36 Yankee otter trawl. During the surveys, total length of American plaice and yellowtail flounder was recorded to the nearest cm. The stages of maturity outlined by Powles (1965) were used in assessing maturity of plaice and yellowtail flounder. Plaice and yellowtail flounder were aged by otoliths according to the method used for cod (Gadus morhua) by Kohler (1964) and validated for plaice by Powles (1965).

The transition from the immature to the mature condition in fish usually occurs over a range of length and age in the form of a sigmoid curve. From the percentage of mature individuals (gonads in ripening, ripe, spawning, spent, or intervals, the median length at sexual maturity was calculated by probit analyses following the technique of Leslie et al. (1945). Median age at maturity was calculated by probit analysis by grouping the data in 1-yr intervals. However, in some cases, annual values for median size and age at sexual maturity could not be calculated because no individuals were sampled in that year or because the data were not available in sufficient quantity to conduct probit analysis.

RESULTS

AMERICAN PLAICE

Div. 4T

American plaice in Div. 4T were sampled consistently only in the 1970s. Median length at maturity for females declined about 50% between 1959-1979, while that of males was relatively constant, except in 1979 (Fig. 2). Median age at maturity for females has also declined about 50% during 1959-1979, while that of males has remained relatively constant (Fig. 3). Median age at maturity for females declined from about 10.4 yr in 1959 to about 5.0 yr in 1979 ($P<0.01$). Males always matured at smaller sizes and younger ages than did females.

Maturity ogives based on length were calculated for the four periods analyzed and they indicated that the ogive shifted towards maturity at smaller sizes (Fig. 4). During 1975-1979, 100% of 40-cm females were mature, but during 1959-1964, only about 50% of 40-cm females were mature. The transition from the 0% mature to 100% mature occurred over a 30-cm length during 1959-1964, but the transition occurred over a 15-cm interval during 1975-1979. Larger, immature females became relatively less abundant in the stock through time.

The maturity ogives based on age indicated that there was a general increase in percentage mature at age through time for females ages 3-13 (Table 1). Owing to this increase in percentage mature at age, median age at maturity for females declined from 9.5 yr during 1959-64 to 6.2 yr during 1975-1979 ($P<0.05$). During 1975-79, over 90% of age-9 females were mature but

only 40% were mature during 1959-1964. The percentage of mature age-6 and -7 females was over 20 times higher during 1975-1979 than during 1959-1964. Over 90% of males were mature by age 8.

Subdiv. 4Vn

As in Div. 4T, American plaice in Subdiv. 4Vn have been sampled consistently only since 1970. Median length at maturity for females declined from about 47 cm in 1960 to 27 cm in 1979 (Fig. 5). Median length at maturity for males has been more stable, but tended to be lower in 1977 and 1978 than previously. Median age at maturity has declined in females from 10.5 yr in 1964 to 6.2 yr in 1979, a decline of 41% ($P<0.01$) (Fig. 6). Median age at maturity in males has also tended to decline from 6.8 yr in 1964 to 5.9 yr in 1979, a decline of 13% ($P<0.05$).

Maturity ogives based on length indicated that there was a marked decline in the relative abundance of larger, immature female plaice. During 1975-1979, all females over 40 cm total length were mature, but only about 55% were mature during 1959-1964 (Fig. 7). Median size at maturity for males declined from 25.2 cm during 1959-1964 to 22.3 cm during 1975-1979 ($P<0.05$).

Exclusive of males during 1959-1964 owing to small sample sizes, median age at maturity decreased and this was illustrated by the increasing percent mature at age over time (Table 2). The increase was most apparent in ages 4-7 for males and ages 5-11 for females. For females, percentage mature at age generally doubled between 1970-1974 and 1975-1979 for ages 5-9. During 1975-1979, median age at maturity was about 5.2 yr for males and 6.7 yr for females.

Subdiv. 4Vs

American plaice in Subdiv. 4Vs were sampled irregularly before 1970. Median length at maturity has declined more in females than in males during 1959-1979, with median lengths in females declining 19 cm (41%) and in males 3 cm (12%) (Fig. 8). Median age at maturity also declined between 1959-79, about 5.8 yr (52%) in females and 1.0 yr (18%) in males (Fig. 9). Males matured at smaller sizes and younger ages than did females.

Maturity ogives based on length indicated that there was a decline in the abundance of larger, immature females. Females 40 cm in total length were about 45% mature from 1959-64 but were 100% mature during 1975-1979 (Fig. 10). The trend for a transition from an immature to a mature state over a smaller length interval through time was also apparent. The transition occurred over a 25-cm length interval during 1959-1964, but over a 15-cm interval during 1975-1979. In the 1970s, virtually all males over 30 cm in length were mature. Median size at maturity for males declined from 26.3 cm during 1959-1964 to 23.9 cm during 1975-1979 ($P<0.05$).

There was a general increase in percentage mature at age through time (Table 3). The increase was most apparent in ages 5-8 for males and ages 5-10 for females. Over 90% of age 8 or older plaice were mature during

1975-1979. Median age at maturity for females declined from 11.5 yr during 1959-1964 to 5.7 yr during 1975-1979, while that for males declined from 5.4-4.6 yr, respectively.

Div. 4W

As with American plaice in the other areas investigated, plaice in Div. 4W were sampled irregularly before 1970. During 1959-1979, median lengths at maturity declined 13 cm (39%) for females and 3 cm (11%) for males (Fig. 11). Median age at maturity for females declined from 11.5 yr in 1964 to 5.1 yr in 1979, a decline of 56% (Fig. 12). Median age at maturity for males declined from 6.7 yr in 1964 to 4.1 yr in 1971, a decline of 39%. Males always matured at smaller sizes and younger ages than did females.

Maturity ogives based on length were calculated for the four periods analyzed, and trends were similar to those in other areas (Fig. 13). During 1975-1979, all 40-cm females were mature, but during 1959-1964, about 75% of 40-cm females were mature. Larger, immature females became less abundant through time. Median length at maturity in males declined from 26.2 cm during 1959-1964 to 22.1 cm during 1975-1979 ($P<0.05$). By 1975-1979, 95% of males 30 cm in length were mature, but about 60% were mature during 1959-1964.

Maturity ogives based on age indicated that there was a general increase in percentage mature at age with time (Table 4). By 1975-1979, over 90% of females were mature by age 8, whereas under 20% of age 8 females were mature during 1959-1964. During 1959-1979, males were over 90% mature at age 7.

Div. 4X

American plaice have been sampled less intensively in Div. 4X than in other areas investigated, due to their relatively lower abundance in Div. 4X (Scott 1976). As with plaice in other areas, median length at maturity generally declined in the 1960s and 1970s, especially for females (Fig. 14). Median age at maturity also declined since 1970, with median age for males declining 2.0 yr (36%) and for females 1.2 yr (20%) (Fig. 15).

The attainment of maturity at progressively smaller sizes with time was less pronounced for plaice in Div. 4X than in the other areas. Whereas all 40-cm female plaice were mature during 1975-1979, about 90% of 40-cm females were mature during 1959-1964 (Fig. 16). About 90% of 30-cm males were mature during 1975-1979, but about 65% of 30-cm males were mature during 1959-1964.

The percentage mature at age generally increased with time (Table 5), so that median age at maturity for males declined from 4.5 yr during 1970-1974 to 3.5 yr during 1975-1979, while that of females declined from 6.0-4.7 yr. The increase in percentage mature at age was most apparent for males ages 4+ and females ages 5+.

Comparisons among areas

Several trends were apparent when all areas were considered in the multi-year grouping of the groundfish surveys. Median lengths at sexual maturity generally declined through time (Table 6), as did median ages at maturity. Males generally matured at smaller sizes and younger ages than did females. American plaice in the more northerly areas (Div. 4T and Subdiv. 4Vn) had older median ages at maturity than did those on the southern Scotian Shelf (Divs. 4W and 4X). Bottom water temperatures derived from July groundfish surveys during 1975-1979 were 3.80°C in Subdiv. 4Vn, 3.99°C in Subdiv. 4Vs, 6.48°C in Div. 4W, and 7.19°C in Div. 4X. Median age at maturity was inversely correlated with bottom water temperatures for males ($r=-0.96$, $n=4$, $P<0.05$) and females ($r=-0.91$, $n=4$, $P<0.10$). Growth rates of American plaice are correlated with water temperatures (Pitt 1967), so there was a trend for American plaice that had slower growth rates to mature at older ages.

YELLOWTAIL FLOUNDER

Division 4T

For yellowtail flounder in Div. 4T, median length at sexual maturity generally declined during 1966 to 1979, with median lengths declining from 28 to 23 cm ($P<0.05$) in females and from 26 to 18 cm ($P<0.05$) in males (Fig. 17), a decline of about 18% and 31% respectively during this interval. Median age at maturity has also declined during 1966 to 1979, but more rapidly than did median length at maturity. Median age at maturity for females declined about 1.8 yr (30%) from 6.1 to 4.3 yr ($P<0.05$), and for males about 2.6 yr (45%) from 5.8 to 3.2 yr ($P<0.05$) (Fig. 18). Males generally matured at smaller sizes and younger ages than did females.

Maturity ogives based on length were calculated for the three periods analyzed, and they indicated that the ogive shifted towards maturity at smaller sizes. Immature yellowtail flounder greater than 30 cm were absent from the population during 1975-1979, and whereas no yellowtail under 20 cm in total length were mature during 1965 to 1969, about 40% of the males and 10% of the females under 20 cm were mature during 1975 to 1979 (Fig. 19).

The maturity ogives based on age indicated that there was a general increase in percentage mature at age through time (Table 7). This increase was most pronounced for males age 3-5 and females age 4-6. During 1975 to 1978, virtually all age-7 yellowtail flounder were mature. Median ages at maturity during 1975 to 1978 were about 3.7 yr for males and 4.3 yr for females, declining significantly ($P<0.05$) compared with those ages at maturity during the 1960s of 5.8 yr and 6.1 yr, respectively.

Subdiv. 4Vs

Yellowtail flounder in Subdiv. 4Vs have been sampled consistently only since 1970 (Table 8). There has been a general decline in median length at sexual maturity during 1966 to 1979, with median lengths in females declining 6 cm (19%) ($P<0.05$) and in males declining 7 cm (23%) ($P<0.05$) (Fig. 20). As in yellowtail in Div. 4T, median age at maturity declined more rapidly during 1966 to 1978 than did median length. Median age at maturity was relatively constant during 1966 to 1972, after which it declined about 1.8 yr (32%) for females and 2.3 yr (44%) for males (Fig. 21). As in Div. 4T yellowtail flounder, males matured at smaller sizes and younger ages than did females.

Maturity ogives based on length indicated that there was a marked decline in the relative abundance of larger, immature yellowtail flounder (Fig. 22). During 1975 to 1979, all males over 30 cm were mature, but during 1965 to 1969, only about 70% were mature. Similarly, virtually all females over 32 cm were mature during 1975 to 1979, but only about 60% were mature during 1965 to 1969.

Median age at maturity decreased for yellowtail flounder in the 1970s and this was illustrated by the increasing percent mature at age over time (Table 8). The increase was most apparent in ages 3 to 5 in both males and females. The percentage of mature age-4 males during 1975 to 1978 was 4.4 times higher than during 1965 to 1969, and the percentage of mature age-5 females was 2.6 times higher during the same period. Median ages at maturity declined from 4.9 to 4.0 yr ($P<0.05$) for males and 5.3 to 4.4 yr ($P<0.05$) for females during this same interval.

Div. 4W

Yellowtail flounder were first sampled in Div. 4W in 1962, although few were aged in the 1960s (Table 9). As with yellowtail flounder in other areas, median length at maturity has declined, but most of this decline occurred in the 1960s, especially for females (Fig. 23). During the 1970s, median length at maturity for females was about 25 cm, while that for males was about 23 to 24 cm. Median age at maturity has been variable, but has shown a slight decline in females, from an average of 4.6 yr during 1965 to 1969 to 3.8 yr during 1975 to 1979 (Fig. 24). Median age at maturity for males declined slightly from 3.7-3.6 yr for the same interval, but the decline was not significant ($P>0.05$).

With data grouped in five-yr periods, maturity ogives based on length for males have been relatively constant, with median length at maturity about 24 cm (Fig. 25). Median length at maturity for females in the 1960s was about 30 cm, but about 25 cm in the 1970s ($P<0.05$). As in other yellowtail flounder populations, larger, immature yellowtail flounder have become relatively less abundant with time.

Maturity ogives based on age have been relatively constant for males, with an increase in the percentage mature at age 3 by two times the largest change noted (Table 9). However, the percentage mature at ages 3 to 5 increased through time for females, and thus median age at maturity declined from 4.6 yr during 1965 to 1969 to 3.8 yr during 1975 to 1979 ($P<0.05$).

Div. 4X

Yellowtail flounder in Div. 4X have not been as extensively sampled as in the other areas investigated, and it was not possible to determine annual variability in median size and age at sexual maturity. The percentage mature by length data indicated that median length at maturity for males was relatively constant at 19-20 cm, but median length at maturity for females increased from 24 cm during 1970 to 1974 to 29 cm from 1975 to 1979, but the increase was not significant ($P>0.05$) (Fig. 26).

Maturity ogives based on length indicated that the percentage mature at ages 3 and 4 increased for males (Table 10), so that median age at maturity declined from 3.2 yr during 1970 to 1974 to 2.0 yr during 1975 to 1979 ($P<0.05$). The percentage mature also increased for age-5 females, and median age at maturity declined from 3.1-2.9 yr during the same interval, but the decline was not significant ($P>0.05$).

Comparisons among areas

Several trends were apparent when all areas were considered in the multi-year grouping of the surveys. Median lengths at sexual maturity generally declined through time, except for yellowtail in Div. 4X (Table 11). Median ages at maturity also decreased through time. Males generally matured at younger ages and smaller sizes than did females. Yellowtail flounder in the more northerly areas, Divs. 4T and Subdiv. 4Vs, had older median ages at maturity than did those on the southern Scotian Shelf (Divs. 4W and 4X). Bottom water temperatures derived from all sets on July groundfish surveys on the Scotian Shelf during 1975 to 1979 were 3.99°C in Subdiv. 4Vs, 6.48°C in Div. 4W, and 7.19°C in Div. 4X. There was some trend for increasing median age at maturity for yellowtail caught in colder waters. Growth rates of yellowtail flounder may be correlated with water temperature (Pitt 1974), so there was a trend for yellowtail flounder that had lower growth rates to mature at older ages.

DISCUSSION

The mean size and age of American plaice and yellowtail flounder in the landings of the commerical fishery in many areas of Subarea 4 has also declined with time (Powles 1969; Beacham 1982a, b). However, this decline in mean size and age of fish in the landings cannot account for the decline in median size and age at sexual maturity. For example, larger, older plaice are not as abundant as they once were, but during 1975-1979, virtually all 40-cm females were mature, but during 1959-1964, 50% of 40-cm females could be mature. In order for the decline in median size and age at sexual maturity to be accounted for by a decline in mean size and age of the stock, sampling gears during 1959-1964 must have selected larger, immature fish while failing to capture smaller, mature ones whereas during 1975-1979 these small, mature fish became available to the gear, an unlikely situation.

Previous research has been conducted on size and age of American plaice in the Northwest Atlantic. Powles (1965) reported that during 1957-1962, 50% of females in Div. 4T matured at 41 cm, while 50% of the males matured at 25 cm, with these lengths corresponding to ages 10 and 6 years, respectively. These data are comparable to those in the present study for females during 1959-1964, but males in the present study matured at smaller sizes and younger ages during 1959-1964 than during 1957-1962. Pitt (1966) found that 50% of female plaice in the Newfoundland area matured from 7.8-15.2 yr, with lower ages at maturity recorded in stocks with faster growth rates in regions of higher water temperatures. Pitt (1966) found that 50% of males matured from 5.3-7.5 yr in age. Pitt (1975) reported that age at maturity of plaice in Divs. 3L and 3N declined during 1969-1972 compared with 1961-1965, but that size at maturity was constant. In the present study, both size and age at maturity has declined. Baegnal (1957) reported that female plaice from the European Clyde population matured at 17-20 cm at age 2-3, but that they lived in areas of relatively high water temperatures.

Previous research has been conducted on size and age at maturity of yellowtail flounder in the Northwest Atlantic. Scott (1954) reported that yellowtail flounder in Div. 4W in 1946 matured at 5 to 7 yr and 30 to 35 cm for males and 6 to 9 yr and 36 to 45 cm for females. These lengths and ages were considerably larger and older than those of the present study, and suggest that median size and age at maturity has declined for at least 30 yr. For yellowtail flounder in NAFO Subarea 5 off New England, Royce et al. (1959) reported that both males and females matured at ages 2-3 and 32 cm in length. Pitt (1970) found that for yellowtail flounder on the Grand and St. Pierre banks near Newfoundland (Subarea 3), median age at maturity was about age 5 for males and age 6 for females, and median lengths were 31 and 37 cm respectively. Values for yellowtail flounder in the present study were less than those of Pitt (1970). However, water temperatures in Pitt's study area were lower than those in the present study, and this could account for the higher ages at maturity for yellowtail flounder in Subarea 3 as compared with those in Subarea 4.

In a study of variability in median size and age at sexual maturity for haddock (Melanogrammus aeglefinus), Templeman and Bishop (1979) attributed a decline in median length at maturity to decreasing growth rates, and a decline in median age at maturity to increasing growth rates. However, Templeman et al. (1978) reported that median age at maturity of Grand Bank haddock declined during 1953-1956 as successful year-classes appeared and the growth rate decreased. Thus median age at maturity declined in periods of increasing and decreasing growth rates, and trends through time may not be simply related to changes in growth rates.

Many groundfish stocks endured high rates of exploitation in the 1960s and early 1970s, and consequently declined in stock biomass. If growth rates of American plaice are inversely correlated with stock biomass, then an increase in growth rate could account for a decline in age at maturity, but it is difficult to account for a decline in size at maturity. Further research is necessary in order to distinguish between selection producing a decline in size and thus age at maturity, or changes in environmental parameters such as stock biomass or temperature accounting for the decline in size and age at maturity.

The present study indicated that American plaice and yellowtail flounder inhabiting regions of warmer water temperatures matured at younger ages than did these same species in regions of colder water temperatures. This same trend was noted by Gunter (1950), who stated that fish inhabiting regions of higher water temperature grew faster initially, attained sexual maturity earlier, and were of smaller final size than the same species in regions of lower water temperature. However, Fleming (1960) found that cod in the Labrador region of Newfoundland attained sexual maturity at younger ages, but grew more slowly than cod in stocks further south. Fleming attributed this result to cod in poorer environments maturing earlier than those in more favourable environments. Alm (1959) noted that fish with a high growth rate attained sexual maturity at an earlier age than did slower-growing fish, and the results of the present study on regional variability in age at maturity support that conclusion.

For American plaice and yellowtail flounder in most of the areas investigated in the present study, median length and age at sexual maturity generally declined through time. To the extent that size and age at maturity has a genetic component (Alm 1959), fish which mature at smaller sizes or younger ages had a selective advantage during an intensive fishery. American plaice and yellowtail flounder have been exploited commercially for many years, and selection would favour those genotypes that reproduce at lengths not fully recruited to the commercial fishery, whereas a genotype that matures at a larger size might be removed before reproduction. This process could account for the decreasing abundance of larger, immature fish through time. It may be, therefore, that late-maturing genotypes were removed from the stocks in a period of heavy exploitation.

In summary, the present study has indicated that median length and age at maturity has generally declined for American plaice and yellowtail flounder in many areas in the Northwest Atlantic Ocean. However, whether this decline can be ascribed to genetic or environmental changes cannot be determined as the application of the selective force (fishing intensity) concurrently changes the environment (stock biomass).

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REFERENCES

Alm, G. 1959. Connection between maturity, size, and age in fishes. Rep. Inst. Freshwater Res. Drottningholm 40: 145 p.

Bagenal, T. B. 1957. The breeding and fecundity of the long rough dab, Hippoglossoides platessoides (Fabr.) and the associated cycle in condition. J. Marine Biol. Assoc. U.K. 36: 339-375.

Beacham, T. D. 1982a. Some aspects of growth and exploitation of American plaice (Hippoglossoides platessoides) in the Canadian Maritimes area of the Northwest Atlantic. Can. Tech. Rep. Fish. Aquat. Sci. 1080: 43 p.

Beacham, T. D. 1982b. Some aspects of growth and exploitation of yellowtail flounder (Limanda ferruginea) in the Canadian Maritimes area of the Northwest Atlantic Ocean. Can. Tech. Rep. Fish. Aquat. Sci. 1092: 27 p.

Cole, L. C. 1954. The population consequences of life history phenomena. Quart. Rev. Biol. 29: 103-137.

Fleming, A. M. 1960. Age, growth, and sexual maturity of cod (Gadus morhua L.) in the Newfoundland area, 1947-50. J. Fish. Res. Board Can. 17: 775-809.

Gunter, G. 1950. Correlation between temperature of water and size of marine fishes on the Atlantic and Gulf coasts of the United States. Copeia 1950(4): 298-304.

Halliday, R. G. 1973. The flatfish fisheries of the Scotian Shelf. Int. Comm. Northwest Atl. Fish. Redbook, Part III: 79-99.

Jean, Y. 1964. Seasonal distribution of cod (Gadus morhua L.) along the Canadian Atlantic coast in relation to water temperature. J. Fish. Res. Board Can. 21: 429-460.

Kohler, A. C. 1964. Variations in the growth of Atlantic cod (Gadus morhua L.). J. Fish. Res. Board Can. 21: 57-100.

Leim, A. H. and W. B. Scott. 1966. Fishes of the Atlantic coast of Canada. Fish. Res. Board Can. Bull. 155: 485 p.

Leslie, P. H., J. S. Perry, and J. S. Watson. 1945. The determination of the median body weight at which female rats reach maturity. Proc. Zool. Soc. Lond. 115: 473-488.

Pitt, T. K. 1966. Sexual maturity and spawning of American plaice, Hippoglossoides platessoides (Fabricius), from Newfoundland and Grand Banks areas. J. Fish. Res. Board Can. 23: 651-672.

1967. Age and growth of American plaice (Hipploglossoides platessoides) in the Newfoundland area of the Northwest Atlantic. J. Fish. Res. Board Can. 24: 1077-1099.

1970. Distribution, abundance, and spawning of yellowtail flounder, Limanda ferruginea, in the Newfoundland area of the Northwest Atlantic. Journal of the Fisheries Research Board of Canada 27: 2261-2271.

1974. Age composition and growth of yellowtail flounder (Limanda ferruginea) from the Grand Bank. J. Fish. Res. Board Can. 31: 1800-1802.

1975. Changes in abundance and certain biological characteristics of Grand Bank American plaice, Hippoglossoides platessoides. J. Fish. Res. Board Can. 32: 1383-1398.

Powles. P. M. 1965. Life history and ecology of American plaice (Hippoglossoides platessoides F.) in the Magdalen Shallows. J. Fish. Res. Board Can. 22: 565-598.

1969. Size changes, mortality, and equilibrium yields in an exploited stock of American plaice, Hippoglossoides platessoides. J. Fish. Res. Board Can. 26: 1205-1235.

Powles, P. M. and A. C. Kohler. 1970. Depth distributions of various stages of witch flounder (Glyptocephalys cynoglossus) off Nova Scotia and in the Gulf of St. Lawrence. J. Fish. Res. Board Can. 27: 2053-2062.

Royce, W. F., R. J. Buller, and E. D. Premetz. 1959. Decline of the yellowtail flounder (Limanda ferruginea) off New England. U.S. Fish Wildlife Service Fisheries Bulletin 146: 169-267.

Scott, D. M. 1954. A comparative study of the yellowtail flounder from three Atlantic fishing areas. J. Fish. Res. Board Can. 11: 171-197.

Scott, J. S. 1976. Summer distribution of groundfish on the Scotian Shelf, 1970-74. Fish. Mar. Serv. Res. Div. Tech. Rep. 635: 51 p.

Stearns, S. C. 1976. Life history tactics: a review of the ideas. Quart. Rev. Biol. 51: 3-47.

Templeman, W., V. M. Hodder, and R. Wells. 1978. Sexual maturity and spawning in haddock, Melanogrammus aeglefinus, of the Southern Grand Bank. Int. Comm. Northwest Atl. Fish. Res. Bull. 13: 53-65.

Templeman, W., and C. A. Bishop. 1979. Sexual maturity and spawning in haddock, Melanogrammus aeglefinus, of St. Pierre Bank. Int. Comm. Northwest. Atl. Fish. Res. Bull. 14: 77-83.

Table 1. Percentage of sexually mature plaice by age and sex caught during Canadian groundfish surveys in Div. 4T during 1959-1979. Sample size are in parentheses after individual ages and 95% confidence limits after A_{50} (yr).

Age (yr)	1959-1964	1970-1974	1975-1979
		Male	
1	0.0 (2)	0.0 (5)	0.0 (5)
2	0.0 (7)	1.3 (75)	1.3 (75)
3	28.6 (14)	3.5 (258)	3.5 (258)
4	23.5 (34)	21.0 (415)	21.0 (415)
5	56.6 (53)	56.5 (372)	56.5 (372)
6	91.3 (69)	79.1 (325)	79.1 (325)
7	90.9 (33)	86.7 (293)	86.7 (263)
8	93.8 (32)	93.4 (259)	93.4 (259)
9	100.0 (26)	95.1 (204)	95.1 (204)
10	100.0 (8)	96.8 (126)	96.8 (126)
11	100.0 (13)	98.8 (85)	98.8 (85)
12	100.0 (7)	100.0 (70)	100.0 (70)
A_{50}	4.48 (4.17-4.81)	4.93 (4.83-5.03)	4.65(4.59-4.72)
		Female	
3	0.0 (6)	0.0 (284)	1.4 (212)
4	0.0 (32)	1.7 (419)	6.4 (625)
5	0.0 (40)	6.0 (350)	24.0 (995)
6	1.4 (72)	17.5 (325)	42.8 (880)
7	3.6 (55)	35.6 (346)	65.7 (852)
8	23.1 (26)	65.5 (348)	82.8 (800)
9	37.7 (37)	84.9 (305)	92.8 (514)
10	59.5 (37)	94.1 (222)	94.3 (368)
11	86.4 (22)	94.9 (137)	98.5 (332)
12	90.0 (30)	97.3 (109)	98.6 (220)
13	93.3 (15)	98.8 (80)	100.0 (198)
14	100.0 (7)	100.0 (91)	100.0 (130)
A_{50}	9.46(9.12-9.80)	7.29(7.17-7.40)	6.18(6.11-6.25)

Table 2. Percentage of sexually mature plaice by sex and age caught during Canadian groundfish surveys in Subdiv. 4Vn during 1959-1979. Sample sizes are in parentheses after individual ages and 95% confidence limits after A_{50} (yr).

Age (yr)	1959-1964	1970-1974	1975-1979
		Male	
2	- (0)	0.0 (3)	0.0 (1)
3	0.0 (1)	0.0 (19)	0.0 (8)
4	100.0 (1)	10.7 (28)	26.1 (23)
5	100.0 (1)	20.8 (48)	39.2 (51)
6	40.0 (5)	59.1 (22)	75.6 (41)
7	100.0 (2)	67.2 (58)	82.1 (39)
8	100.0 (2)	89.5 (76)	83.3 (24)
9	50.0 (2)	86.8 (53)	100.0 (29)
10	100.0 (2)	88.6 (35)	95.5 (22)
11	100.0 (1)	95.2 (21)	100.0 (27)
12	50.0 (2)	100.0 (22)	100.0 (15)
A_{50}	-	5.84(5.04-6.18)	5.18(4.79-5.60)
		Female	
3	- (0)	0.0 (13)	0.0 (3)
4	- (0)	3.2 (31)	5.0 (20)
5	0.0 (1)	3.2 (31)	5.6 (54)
6	0.0 (2)	19.4 (36)	34.1 (44)
7	0.0 (4)	25.5 (47)	66.7 (42)
8	0.0 (2)	37.3 (59)	81.0 (42)
9	28.6 (7)	46.7 (45)	83.3 (30)
10	50.0 (2)	73.0 (37)	100.0 (28)
11	50.0 (2)	60.0 (15)	96.2 (26)
12	100.0 (2)	93.8 (16)	90.0 (20)
13	100.0 (3)	92.9 (14)	95.0 (20)
14	100.0 (2)	81.8 (11)	90.0 (10)
15	100.0 (1)	100.0 (10)	100.0 (10)
A_{50}	-	8.78(8.29-9.29)	6.65(6.34-6.97)

Table 3. Percentage of sexually mature plaice by sex and age caught during Canadian groundfish surveys in Subdiv. 4Vs during 1959-1979. Sample sizes are in parentheses after individual ages and 95% confidence limits after A_{50} (yr).

Age (yr)	1959-1964	1970-1974	1975-1979
		Male	
2	-	2.6 (38)	0.0 (16)
3	0.0 (3)	15.0 (60)	8.0 (112)
4	66.7 (6)	28.9 (90)	26.1 (211)
5	42.9 (7)	54.5 (123)	68.7 (182)
6	50.0 (10)	69.6 (158)	78.3 (129)
7	55.6 (9)	76.8 (185)	94.2 (104)
8	50.0 (6)	88.6 (193)	98.8 (163)
9	100.0 (5)	90.8 (131)	96.8 (189)
10	100.0 (1)	95.1 (81)	99.4 (163)
11	100.0 (1)	87.2 (39)	98.6 (70)
12	100.0 (2)	97.1 (34)	100.0 (41)
13	100.0 (4)	100.0 (11)	100.0 (16)
A_{50}	5.35(3.93-7.29)	4.86(4.63-5.11)	4.60(4.47-4.73)
		Female	
2	0.0 (3)	3.0 (33)	0.0 (8)
3	0.0 (2)	7.0 (57)	1.3 (79)
4	0.0 (9)	5.6 (90)	5.2 (193)
5	0.0 (14)	14.0 (93)	32.5 (209)
6	0.0 (7)	34.2 (149)	62.3 (154)
7	5.6 (18)	42.6 (148)	81.9 (127)
8	0.0 (9)	57.7 (196)	90.4 (136)
9	25.0 (8)	76.8 (151)	93.4 (151)
10	50.0 (4)	86.4 (103)	98.2 (162)
11	60.0 (5)	94.7 (76)	99.3 (145)
12	50.0 (6)	87.9 (58)	99.0 (99)
13	50.0 (2)	94.9 (39)	98.1 (52)
14	66.7 (3)	100.0 (43)	100.0 (26)
15	100.0 (1)	95.5 (22)	100.0 (23)
16	100.0 (1)	100.0 (27)	100.0 (9)
A_{50}	11.49(9.93-13.29)	7.08(6.85-7.32)	5.69(5.55-5.83)

Table 4. Percentages of sexually mature plaice by age and sex caught during Canadian groundfish surveys in Div. 4W, 1959-1979. Sample sizes are in parentheses after individual ages and 95% confidence limits after A_{50} (yr).

Age (yr)	1959-1964	1970-1974	1975-1979
		Male	
1	- (0)	0.0 (8)	0.0 (3)
2	- (0)	4.0 (99)	9.4 (32)
3	42.9 (14)	20.7 (188)	29.8 (104)
4	41.2 (17)	42.4 (184)	54.1 (170)
5	45.0 (20)	68.5 (200)	75.3 (146)
6	81.8 (11)	76.8 (155)	83.0 (200)
7	61.9 (21)	86.1 (158)	90.8 (152)
8	85.7 (7)	84.3 (108)	95.0 (100)
9	50.0 (10)	85.0 (60)	92.5 (53)
10	66.7 (6)	75.0 (40)	95.7 (47)
11	66.7 (3)	63.2 (19)	100.0 (18)
12	40.0 (5)	86.4 (22)	100.0 (19)
13	100.0 (7)	60.0 (5)	100.0 (6)
14	66.7 (3)	100.0 (6)	100.0 (4)
15	100.0 (1)	100.0 (1)	100.0 (1)
A_{50}	4.49(2.92-6.90)	4.39(4.19-4.60)	3.79(3.85-4.00)
		Female	
2	0.0 (2)	0.0 (94)	0.0 (24)
3	0.0 (15)	3.6 (139)	10.0 (90)
4	0.0 (16)	12.1 (149)	23.4 (171)
5	8.0 (25)	24.1 (162)	37.0 (138)
6	30.8 (13)	35.3 (133)	68.7 (214)
7	15.2 (33)	44.1 (152)	78.3 (175)
8	0.0 (16)	58.4 (137)	92.2 (128)
9	18.8 (16)	65.0 (100)	93.7 (95)
10	47.4 (19)	62.0 (79)	97.3 (75)
11	36.8 (19)	66.1 (62)	96.7 (60)
12	71.4 (7)	77.6 (49)	92.5 (67)
13	75.0 (4)	86.4 (22)	100.0 (43)

Table 4 (cont'd)

Age (yr)	1959-1964	1970-1974	1975-1979
14	77.8 (9)	100.0 (17)	100.0 (24)
15	75.0 (8)	90.0 (10)	100.0 (17)
16	87.5 (8)	91.7 (12)	100.0 (12)
17	100.0 (3)	100.0 (2)	100.0 (7)
A50	11.21(9.95-12.63)	7.57(7.24-7.92)	5.10(4.94-5.27)

Table 5. Percentage of sexually mature plaice by age and sex caught during Canadian groundfish surveys in Division 4X, 1970-1979. Sample sizes are in parentheses after individual ages and 95% confidence limits after A_{50} (yr).

Age (yr)	1970-1974	1975-1979
	Male	
2	3.6 (28)	22.2 (18)
3	36.8 (68)	22.2 (36)
4	40.0 (75)	66.7 (51)
5	54.6 (77)	75.0 (28)
6	63.4 (41)	92.6 (27)
7	75.0 (24)	88.5 (26)
8	92.6 (27)	100.0 (4)
9	93.3 (15)	100.0 (2)
10	62.5 (8)	100.0 (3)
11	100.0 (4)	100.0 (2)
A_{50}	4.45(4.06-4.87)	3.50(3.17-3.87)
	Female	
2	0.0 (28)	15.4 (26)
3	7.5 (67)	15.8 (38)
4	28.6 (105)	25.9 (58)
5	33.0 (94)	61.7 (47)
6	38.8 (67)	73.0 (37)
7	56.6 (53)	79.1 (43)
8	72.3 (47)	81.5 (27)
9	85.1 (47)	100.0 (16)
10	90.2 (41)	100.0 (14)
11	94.3 (35)	100.0 (11)
12	100.0 (20)	100.0 (12)
A_{50}	5.95(5.62-6.29)	4.70(4.30-5.13)

Table 6. Median length (cm) at sexual maturity and 95% confidence limits of plaice in Divisions 4T, 4V, 4W, and 4X as derived from Canadian groundfish surveys from 1959-1964, 1965-1969, 1970-1974, and 1975-1979.

	Males			
Division	1959-1964	1965-1969	1970-1974	1975-1979
4T	21.86	23.84	22.17	20.46
	(21.35-22.38)	(22.99-24.72)	(21.90-22.45)	(20.28-20.64)
4Vn	25.20	-	23.45	22.33
	(24.46-25.96)		(22.82-24.10)	(21.44-23.25)
4Vs	26.27	28.10	23.12	23.90
	(24.54-28.13)	(25.76-30.65)	(22.67-23.57)	(23.51-24.29)
4W	26.23	22.94	22.07	22.07
	(25.46-27.02)	(22.20-23.70)	(21.69-22.45)	(21.59-22.56)
4X	25.30	28.87	24.80	21.93
	(23.62-27.11)	(27.55-30.25)	(23.84-25.79)	(20.75-23.16)

	Females			
Division	1959-1964	1965-1969	1970-1974	1975-1979
4T	40.84	32.54	30.84	26.96
	(40.07-41.62)	(30.93-34.23)	(30.59-31.10)	(26.74-27.18)
4Vn	37.09	-	31.75	27.63
	(35.74-38.48)		(30.79-32.73)	(26.70-28.60)
4Vs	41.36	38.41	30.53	28.53
	(39.20-43.65)	(37.25-39.60)	(30.10-30.96)	(28.14-28.93)
4W	37.11	35.09	32.35	27.17
	(36.17-38.06)	(34.43-35.77)	(31.84-32.86)	(26.76-27.58)
4X	31.64	35.25	31.04	30.80
	(29.86-33.52)	(34.19-36.34)	(30.37-31.74)	(29.99-31.64)

Table 7. Percentage of sexually mature yellowtail flounder by age and sex caught during Canadian groundfish surveys in the southern Gulf of St. Lawrence, 1965-1978. Sample sizes are in parenthesis after individual ages and 95% confidence limits after A_{50} (yr).

Age (yr)	1965-1969	1970-1974	1975-1978
		Male	
2	0.0 (2)	- (0)	0.0 (6)
3	4.8(21)	21.4(14)	33.3(48)
4	11.5(26)	28.6(42)	51.6(124)
5	9.1(11)	53.9(52)	80.1(156)
6	71.4 (7)	88.7(62)	88.2(127)
7	66.7 (3)	90.8(65)	95.6(91)
8	100.0 (4)	97.7(44)	91.2(34)
9	- (0)	90.0(10)	100.0 (7)
10	100.0 (2)	100.0 (1)	100.0 (2)
A_{50}	5.80(4.99-6.73)	4.55(4.25-4.87)	3.74(3.50-3.99)
		Female	
2	0.0 (1)	50.0 (2)	18.2(11)
3	8.0(25)	45.5(22)	12.5(40)
4	17.9(39)	28.2(39)	36.0(114)
5	38.9(18)	51.2(86)	62.4(149)
6	47.6(21)	78.0(118)	90.5(178)
7	80.0 (5)	85.0(153)	99.5(183)
8	80.0 (5)	89.7(126)	100.0(141)
9	100.0 (2)	98.4(61)	100.0(66)
10	100.0 (1)	84.6(26)	100.0(40)
11	- (0)	83.3 (6)	100.0(12)
12	- (0)	100.0 (3)	100.0 (1)
A_{50}	6.14(5.18-7.23)	4.28(3.88-4.71)	4.30(4.14-4.48)

Table 8. Percentage of sexually mature yellowtail flounder by age and sex caught during Canadian groundfish surveys in Subdiv. 4Vs, 1965-1978. Sample sizes are in parenthesis after individual ages and 95% confidence limits after A_{50} (yr).

Age (yr)	1965-1969	1970-1974	1975-1978
		Male	
2	0.0 (4)	0.0(12)	0.0 (1)
3	4.4(23)	4.7(43)	9.1(33)
4	11.5(26)	37.5(48)	50.7(71)
5	56.4(55)	46.2(78)	81.6(87)
6	81.7(71)	80.0(160)	97.7(88)
7	95.4(43)	93.6(235)	99.4(159)
8	91.7(12)	95.6(135)	100.0(106)
9	100.0 (6)	95.8(48)	100.0(20)
10	100.0 (1)	100.0(18)	100.0 (2)
11	- (0)	100.0 (4)	- (0)
A_{50}	4.87(4.61-5.14)	4.73(4.52-4.96)	4.02(3.84-4.21)
		Female	
2	0.0 (6)	0.0(13)	0.0 (3)
3	0.0(16)	0.0(37)	7.7(36)
4	10.5(38)	22.2(45)	29.9(77)
5	28.6(49)	31.5(92)	74.5(106)
6	83.9(56)	69.9(146)	91.8(73)
7	91.7(60)	92.5(199)	98.5(132)
8	96.2(52)	95.2(210)	100.0(183)
9	95.0(20)	100.0(103)	100.0(79)
10	100.0(11)	100.0(38)	100.0(23)
A_{50}	5.30(5.06-5.55)	5.26(5.08-5.45)	4.38(4.21-4.56)

Table 9. Percentage of sexually mature yellowtail flounder by age and sex caught during Canadian groundfish surveys in Div. 4W, 1965-1978. Sample sizes are in parenthesis after individual ages and 95% confidence limits after A_{50} (yr).

Age (yr)	1965-1969	1970-1974	1975-1978
		Male	
2	0.0 (2)	1.5(68)	2.3(44)
3	15.8(19)	31.9(135)	29.4(160)
4	62.5(56)	65.2(224)	66.3(246)
5	92.5(93)	86.2(326)	85.2(264)
6	98.1(155)	95.9(268)	89.6(241)
7	100.0(22)	99.0(195)	96.6(149)
8	100.0 (6)	98.5(66)	97.5(40)
9	100.0 (4)	100.0(13)	100.0 (5)
A_{50}	3.71(3.48-3.96)	3.54(3.42-3.67)	3.56(3.42-3.70)
		Female	
1	- (0)	0.0 (2)	0.0 (1)
2	0.0 (4)	1.8(57)	0.0(24)
3	5.9(17)	12.4(121)	21.9(137)
4	20.5(39)	37.9(190)	56.0(241)
5	66.4(104)	70.4(304)	84.9(284)
6	91.5(130)	90.1(363)	95.4(328)
7	97.2(36)	96.7(301)	96.8(285)
8	100.0(20)	99.4(178)	100.0(138)
9	100 0 (5)	97.1(68)	100.0(35)
10	100.0(10)	100.0(21)	100.0(16)
A_{50}	4.58(4.39-4.77)	4.25(4.13-4.38)	3.79(3.67-3.90)

Table 10. Percentages of sexually mature yellowtail flounder by age and sex caught during trawls by Canadian groundfish surveys in Division 4X, 1970-1978. Sample sizes are in parentheses for individual ages and 95% confidence limits for A_{50} (yr).

Age (yr)	1970-1974	1975-1978
	Male	
2	- (0)	45.5(11)
3	44.4(18)	83.3(18)
4	75.0(16)	92.6(27)
5	94.7(19)	96.6(29)
6	100.0 (9)	100.0(13)
A_{50}	3.17(2.76-3.65)	2.03(1.50-2.74)
	Female	
2	50.0 (2)	40.0 (5)
3	33.3 (6)	0.0 (3)
4	66.7 (9)	68.8(16)
5	66.7(12)	95.7(23)
6	78.6(14)	81.8(22)
7	80.0(15)	100.0(19)
8	100.0 (3)	100.0 (9)
A_{50}	3.13(1.82-5.40)	2.94(2.26-3.82)

Table 11. Median length (cm) at sexual maturity, and 95% confidence limits of yellowtail flounder in Divs. 4T, 4W, 4X and Subdiv. 4Vs as derived from Canadian groundfish surveys during 1959-1964, 1965-1969, 1970-1974, and 1975-1979.

Division	1959-1964	1965-1969	1970-1974	1975-1979
			Males	
4T	-	26.84 (25.92-27.80)	21.90 (21.14-22.69)	20.54 (19.99-21.11)
4Vs	-	28.14 (27.54-28.76)	24.58 (23.96-25.21)	24.37 (23.79-24.96)
4W	24.60 (23.50-25.74)	23.94 (23.51-24.38)	23.09 (22.75-23.43)	24.26 (23.90-24.63)
4X	-	-	18.74 (17.83-19.69)	20.09 (17.80-22.66)
			Females	
4T	-	26.90 (26.19-27.64)	24.32 (23.66-25.01)	23.35 (23.00-23.69)
4Vs	-	31.60 (31.02-32.18)	27.00 (26.52-27.49)	26.55 (25.98-27.13)
4W	30.31 (29.37-31.28)	30.20 (29.43-31.05)	25.66 (25.39-25.93)	25.28 (24.92-25.64)
4X	-	-	23.88 (20.36-28.01)	29.41 (27.81-31.11)

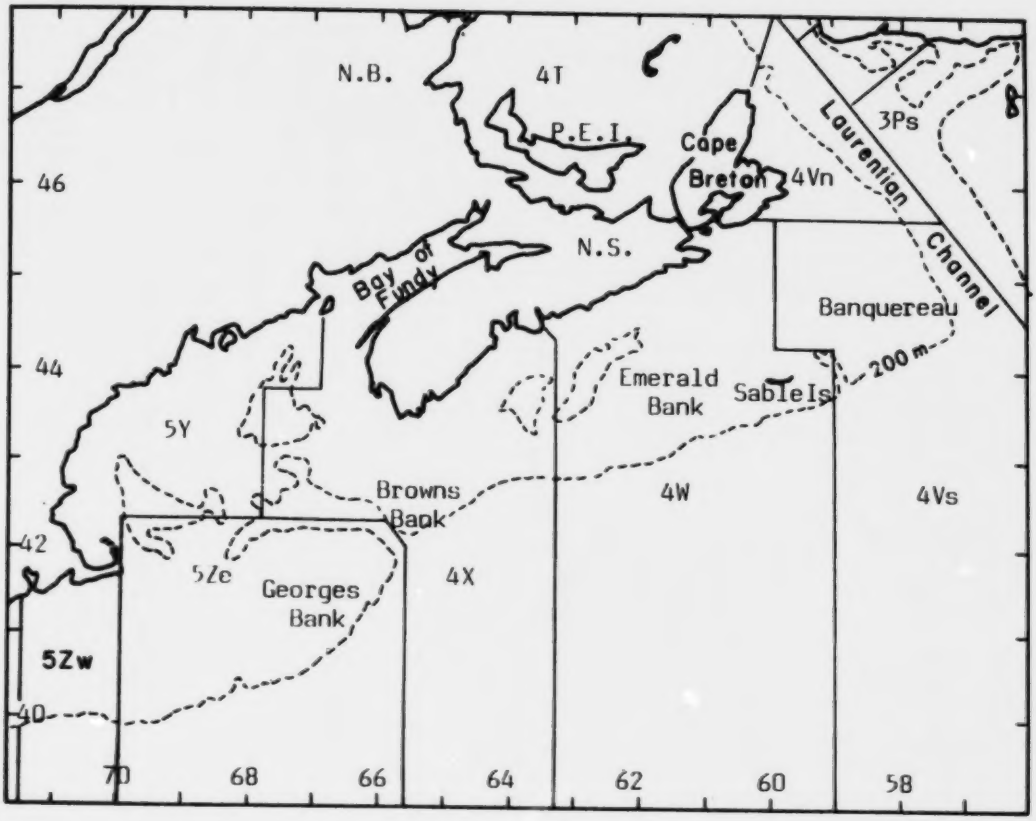

Fig. 1. Northwest Atlantic Fisheries Organization Division in Subarea 4.

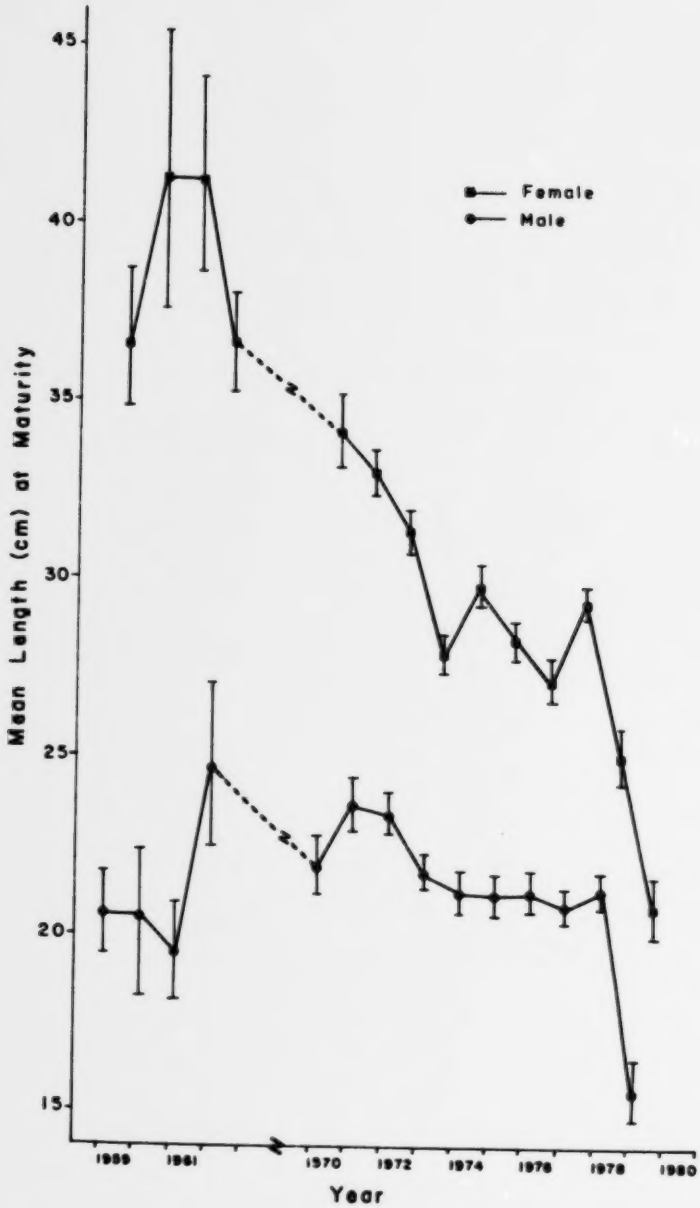

Fig. 2. Median length at sexual maturity for American plaice during September groundfish surveys in Div. 4T, 1959-1979. Vertical bars indicate 95% confidence limits.

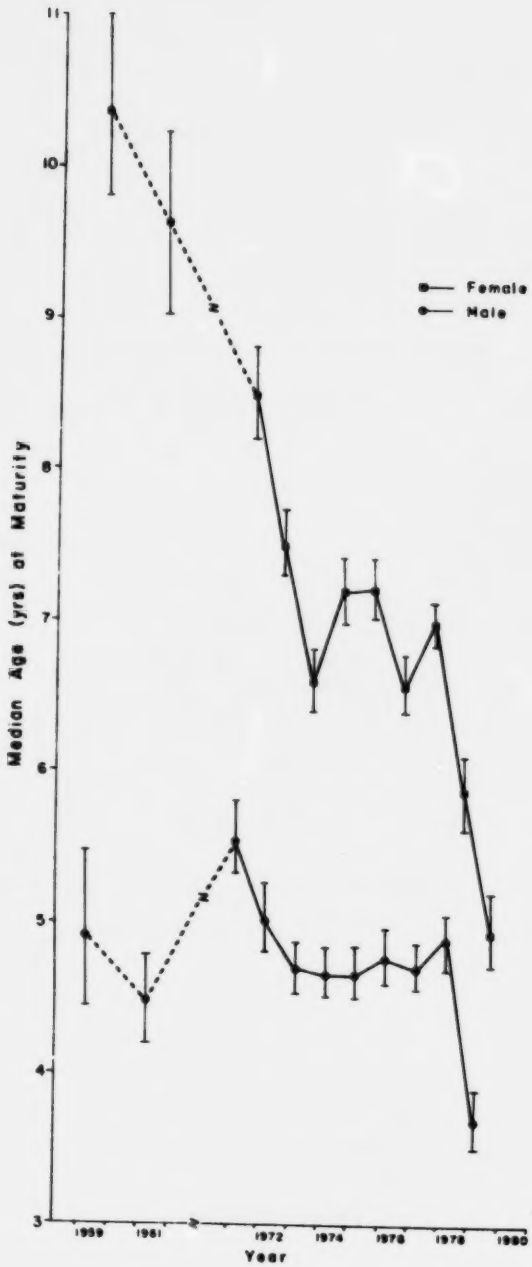

Fig. 3. Median age at sexual maturity for American plaice during September groundfish surveys in Div. 4T, 1959-1979. Vertical bars indicate 95% confidence limits.

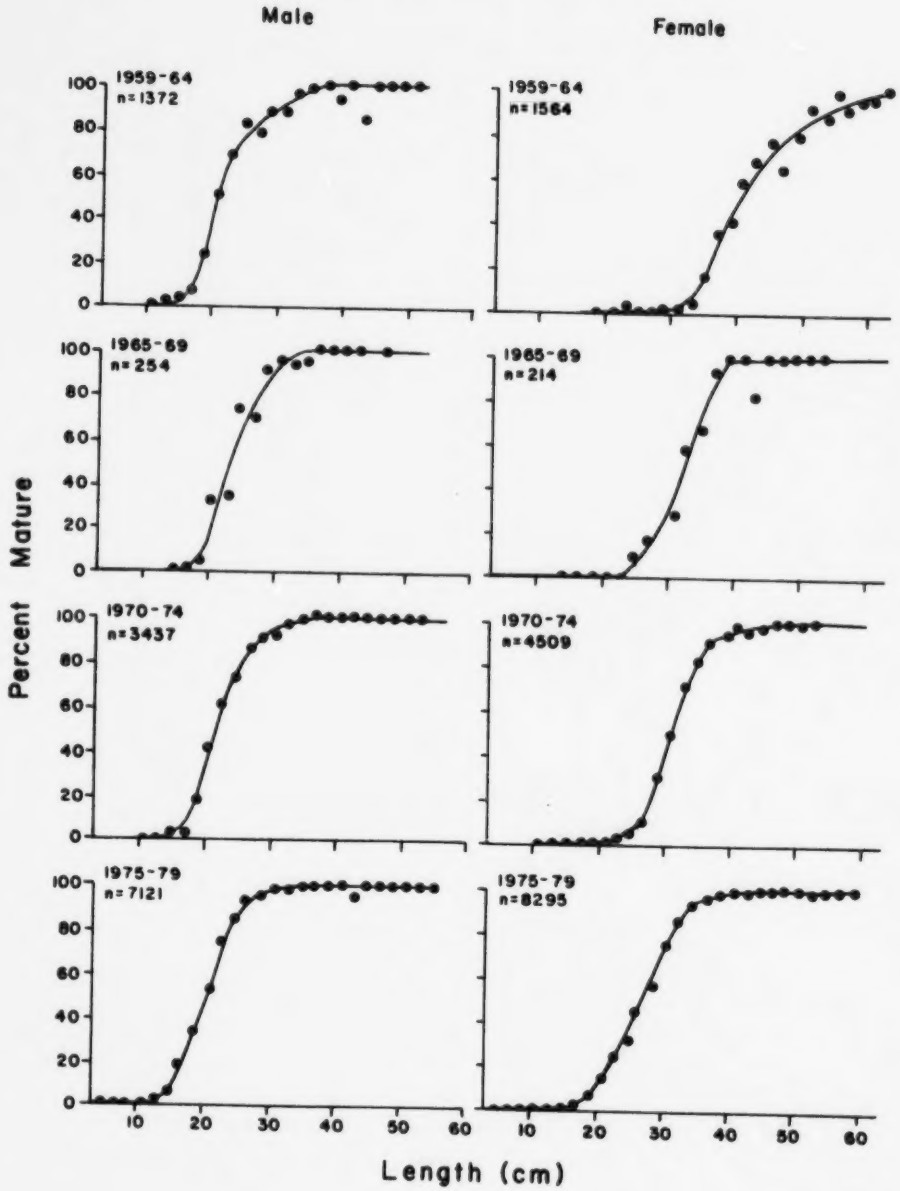

Fig. 4. Maturity ogives for American plaice caught during Canadian groundfish surveys in Div. 4T, 1959-1979.

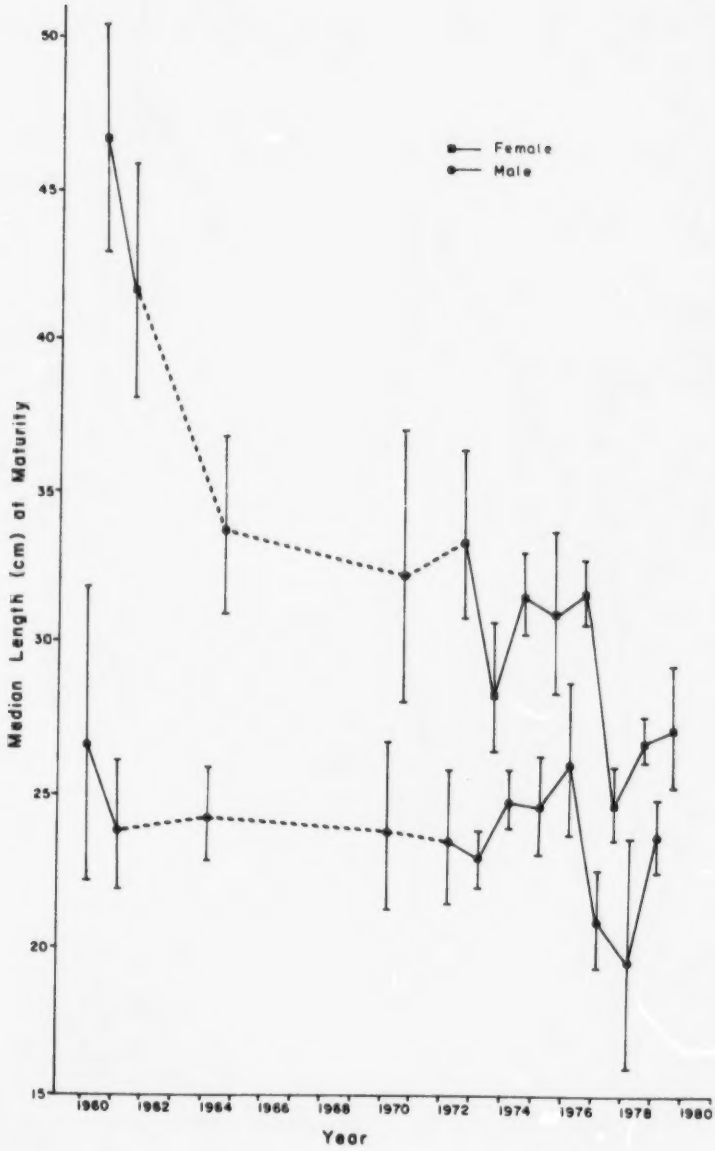

Fig. 5. Median length at sexual maturity for American plaice during summer groundfish surveys in Subdiv. 4Vn, 1959-1979. Vertical bars indicate 95% confidence limits.

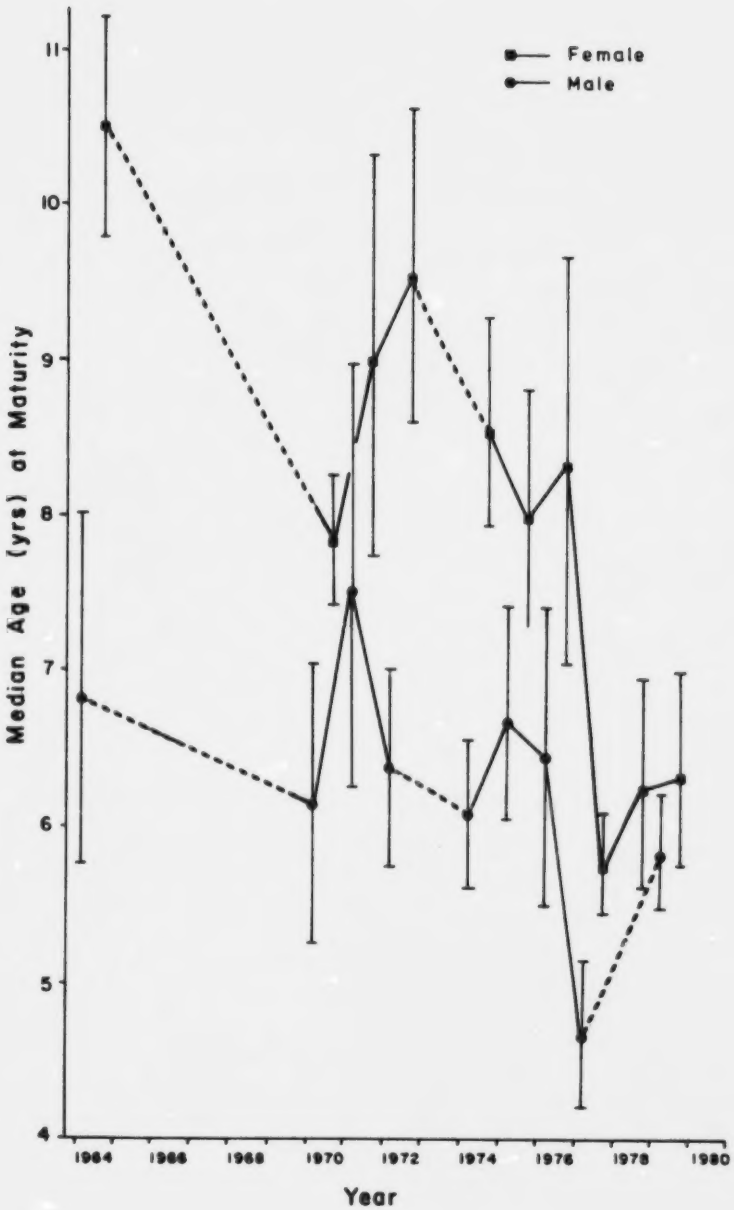

Fig. 6. Median age at sexual maturity for American plaice during summer groundfish surveys in Subdiv. 4Vn, 1959-1979. Vertical bars indicate 95% confidence limits.

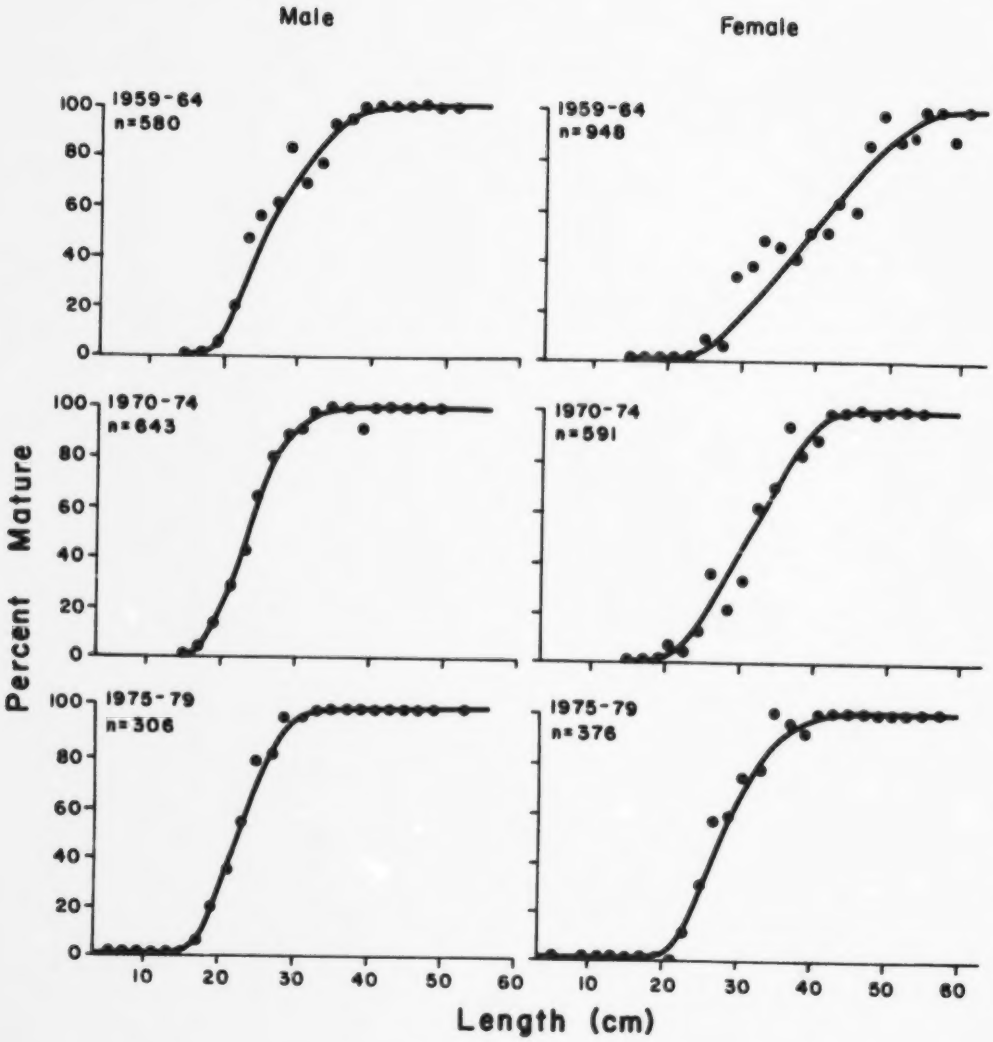

Fig. 7. Maturity ogives for American plaice caught during Canadian groundfish surveys in Subdiv. 4Vn, 1959-1979.

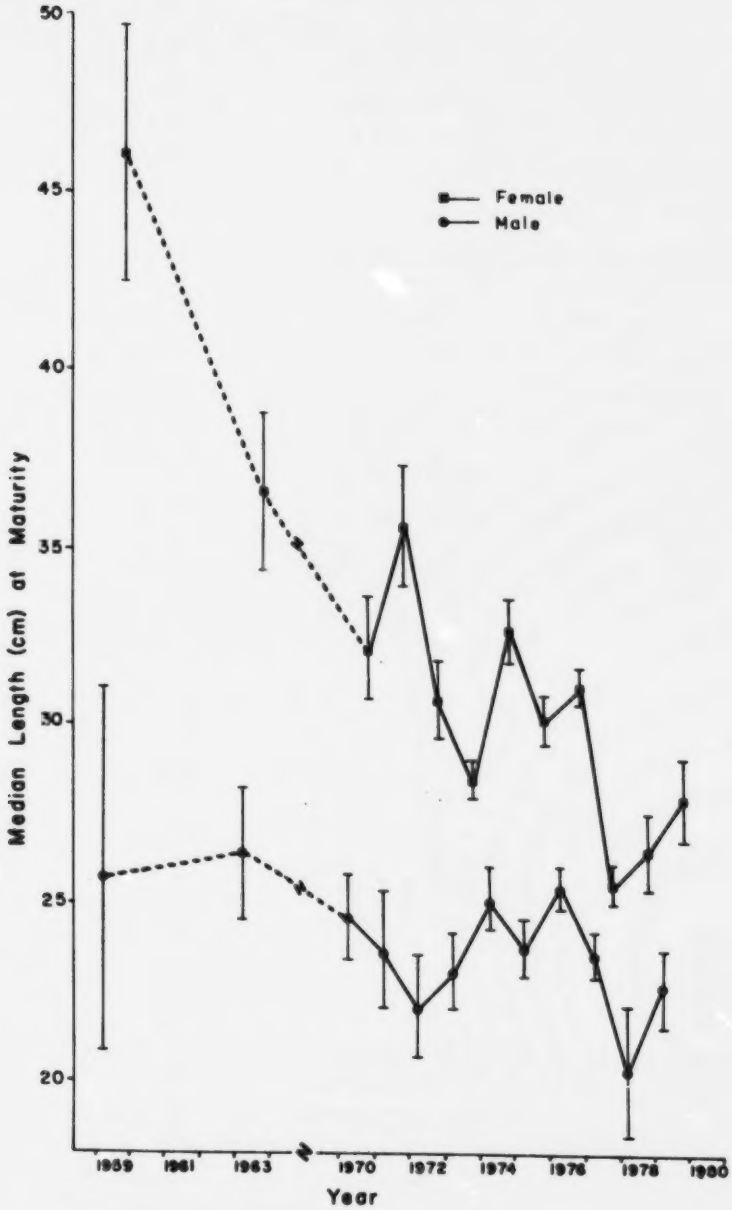

Fig. 8. Median length at sexual maturity for American plaice during summer groundfish surveys in Subdiv. 4Vs, 1959-1979. Vertical bars indicate 95% confidence limits.

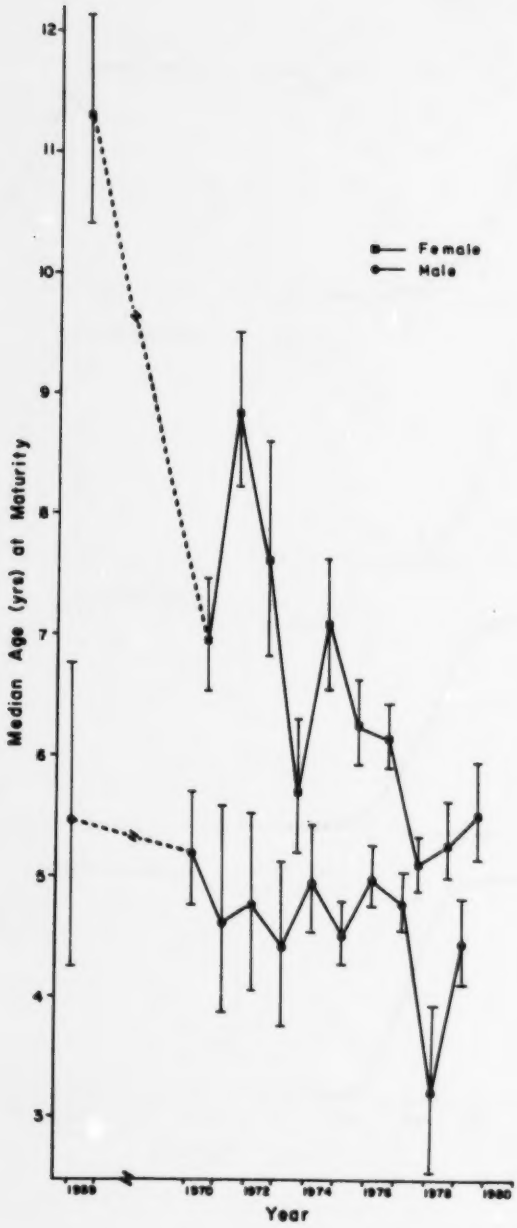

Fig. 9. Median age at sexual maturity of American plaice during summer groundfish surveys in subdiv. 4Vs, 1959-1979. Vertical bars indicate 95% confidence limits.

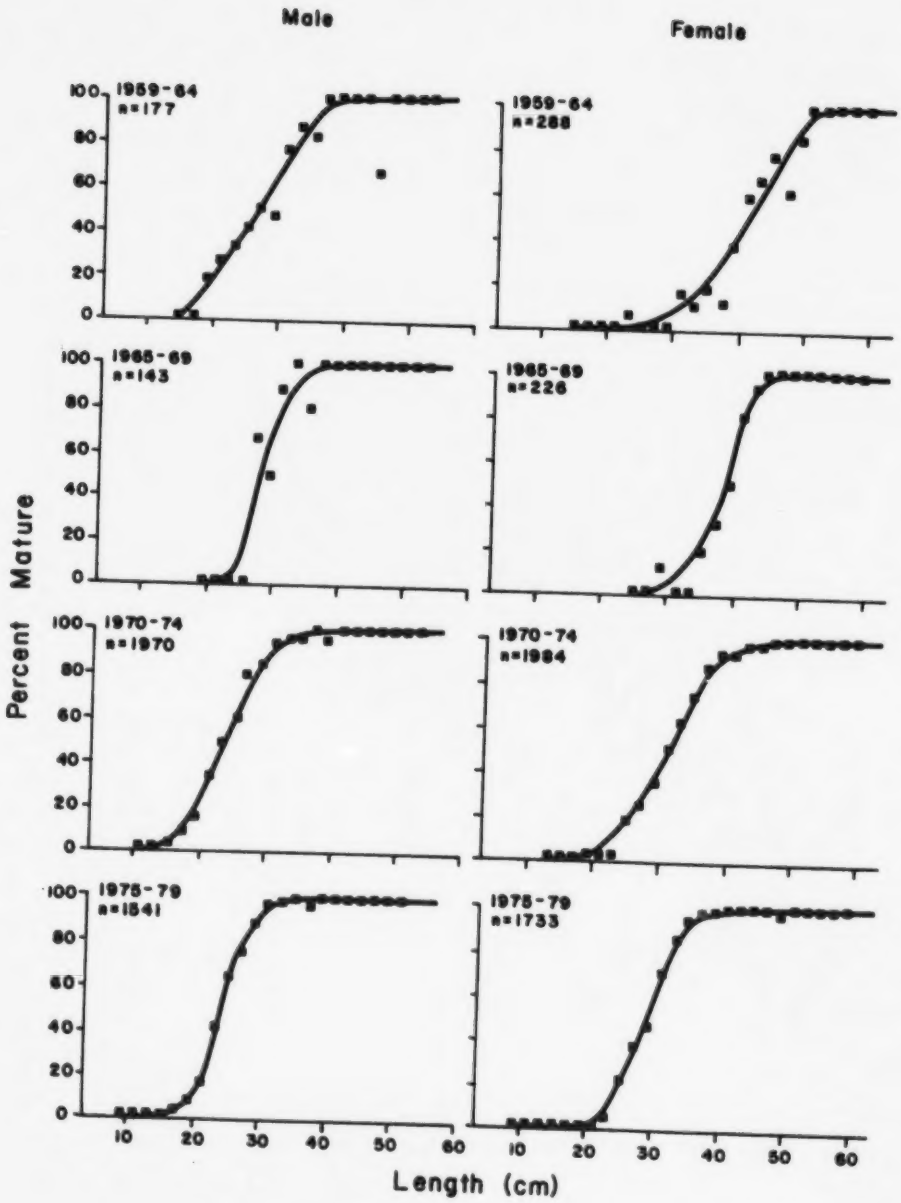

Fig. 10. Maturity ogives for American plaice caught during Canadian groundfish surveys in Subdiv. 4Vs, 1959-1979.

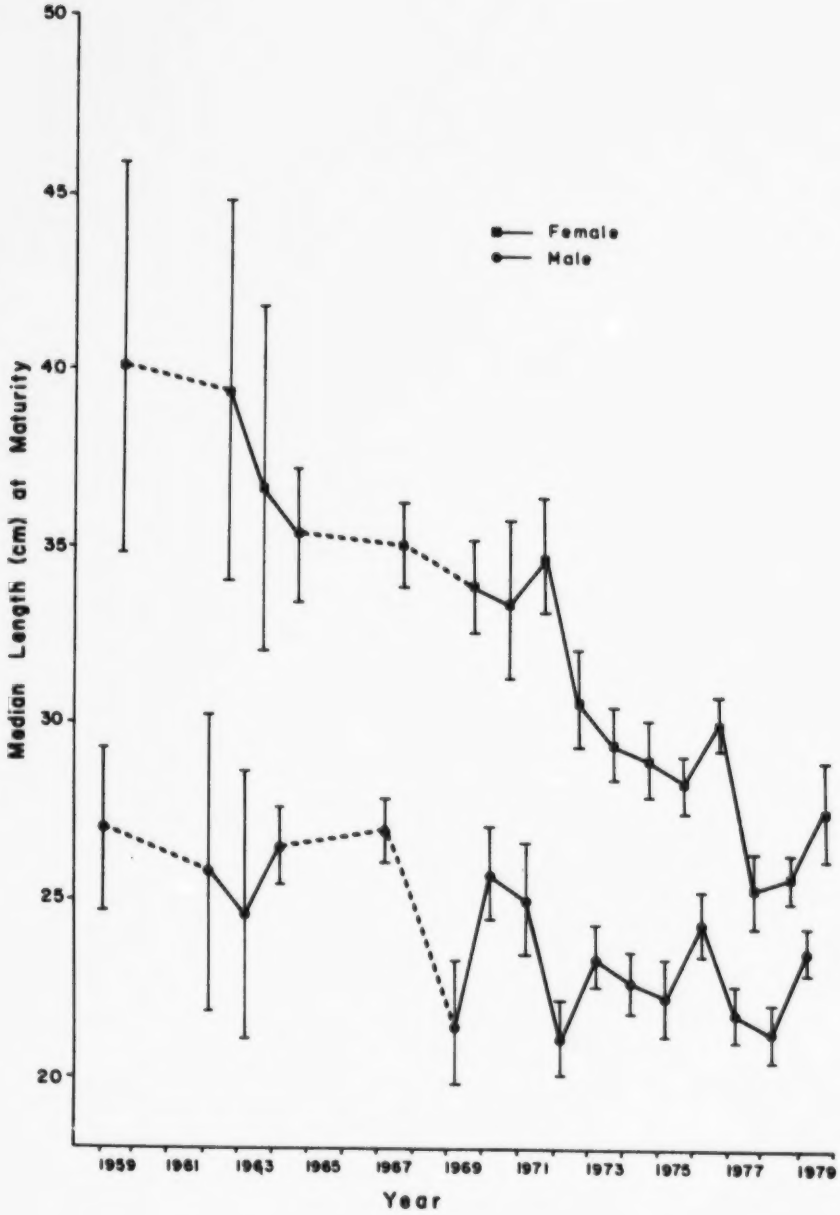

Fig. 11. Median length at sexual maturity for American plaice caught during summer Canadian groundfish surveys in Div. 4W, 1959-1979. Vertical bars indicate 95% confidence limits.

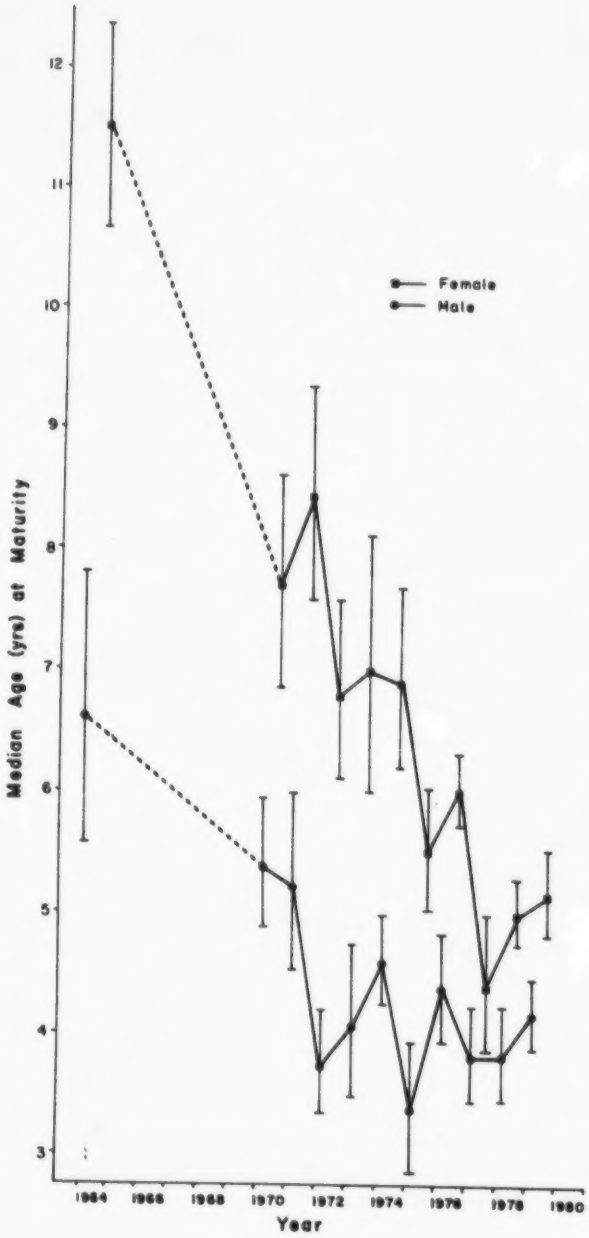

Fig. 12. Median age at sexual maturity for American plaice caught during summer Canadian groundfish surveys in Div. 4W, 1959-1979. Vertical bars indicate 95% confidence limits.

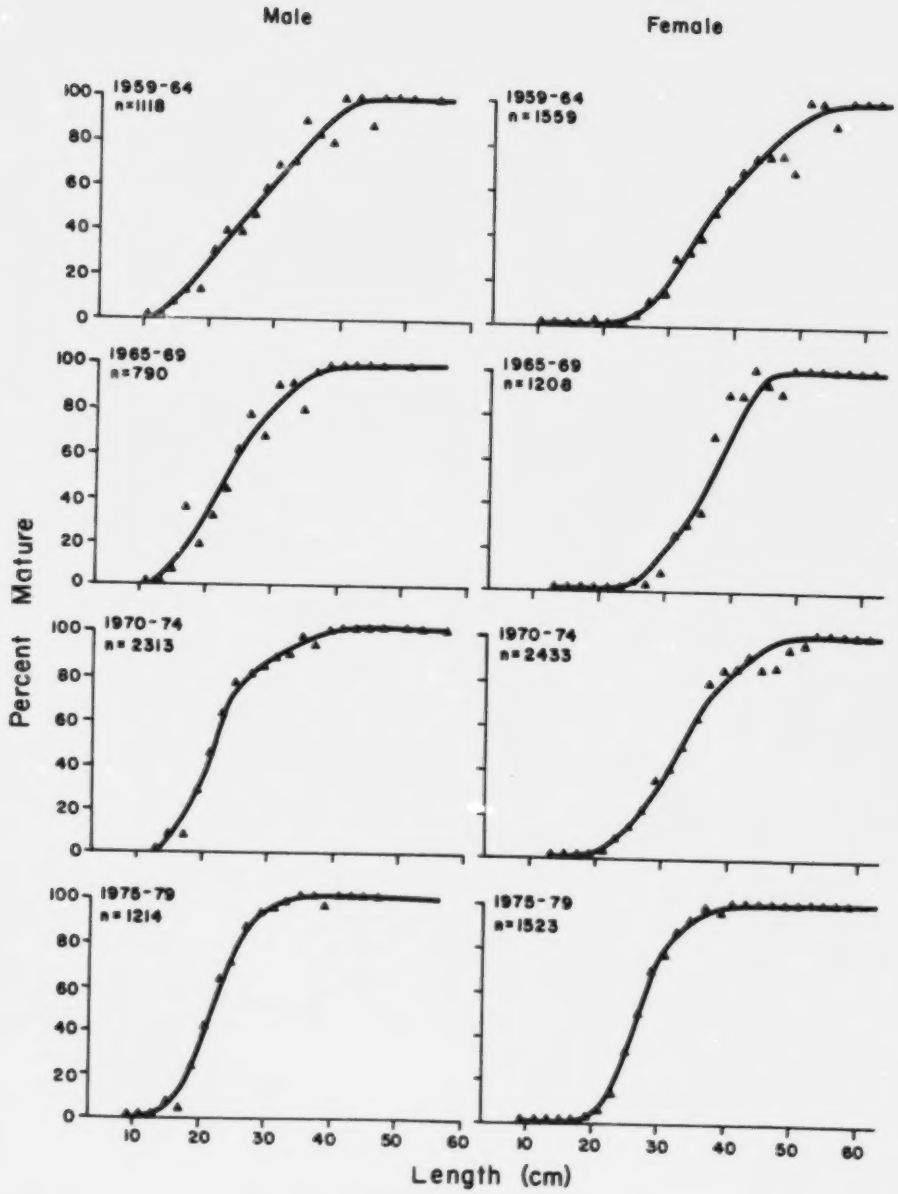

Fig. 13. Maturity ogives for American plaice caught during Canadian groundfish surveys in Div. 4W, 1959-1979.

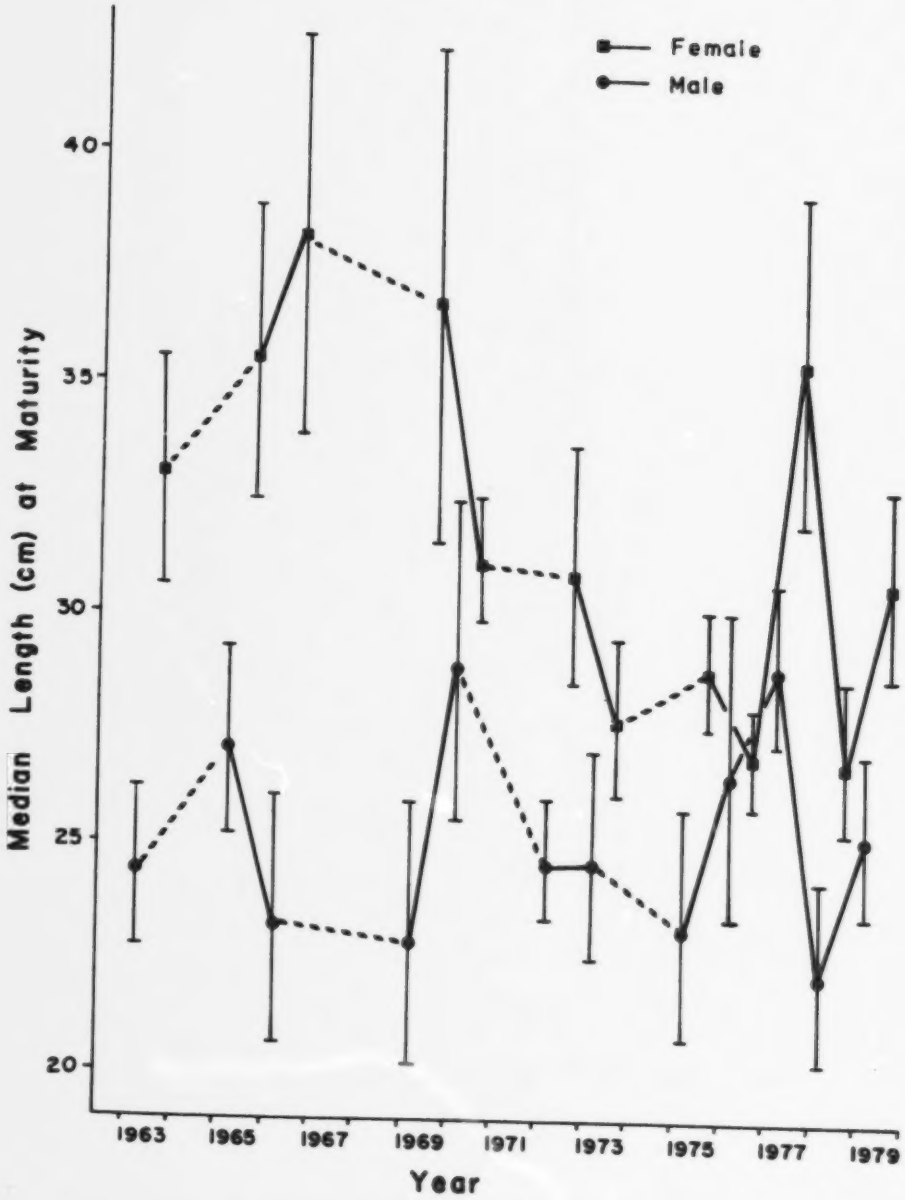

Fig. 14. Median length at sexual maturity for American plaice caught during summer groundfish surveys in Div. 4X, 1963-1979. Vertical bars indicate 95% confidence limits.

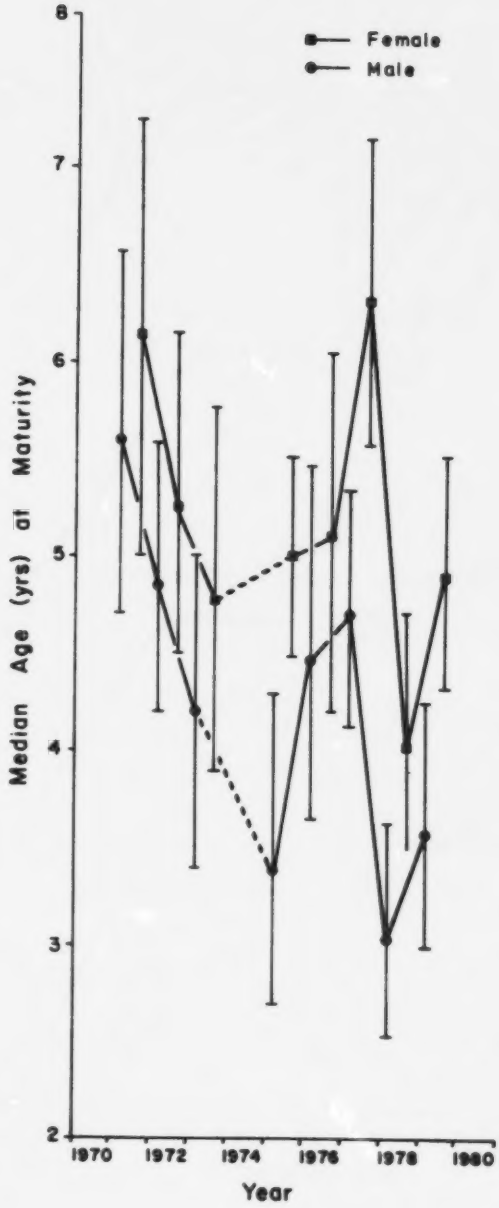

Fig. 15. Median age at sexual maturity of American plaice caught during summer groundfish surveys in Div. 4X, 1970-1979. Vertical bars indicate 95% confidence limits.

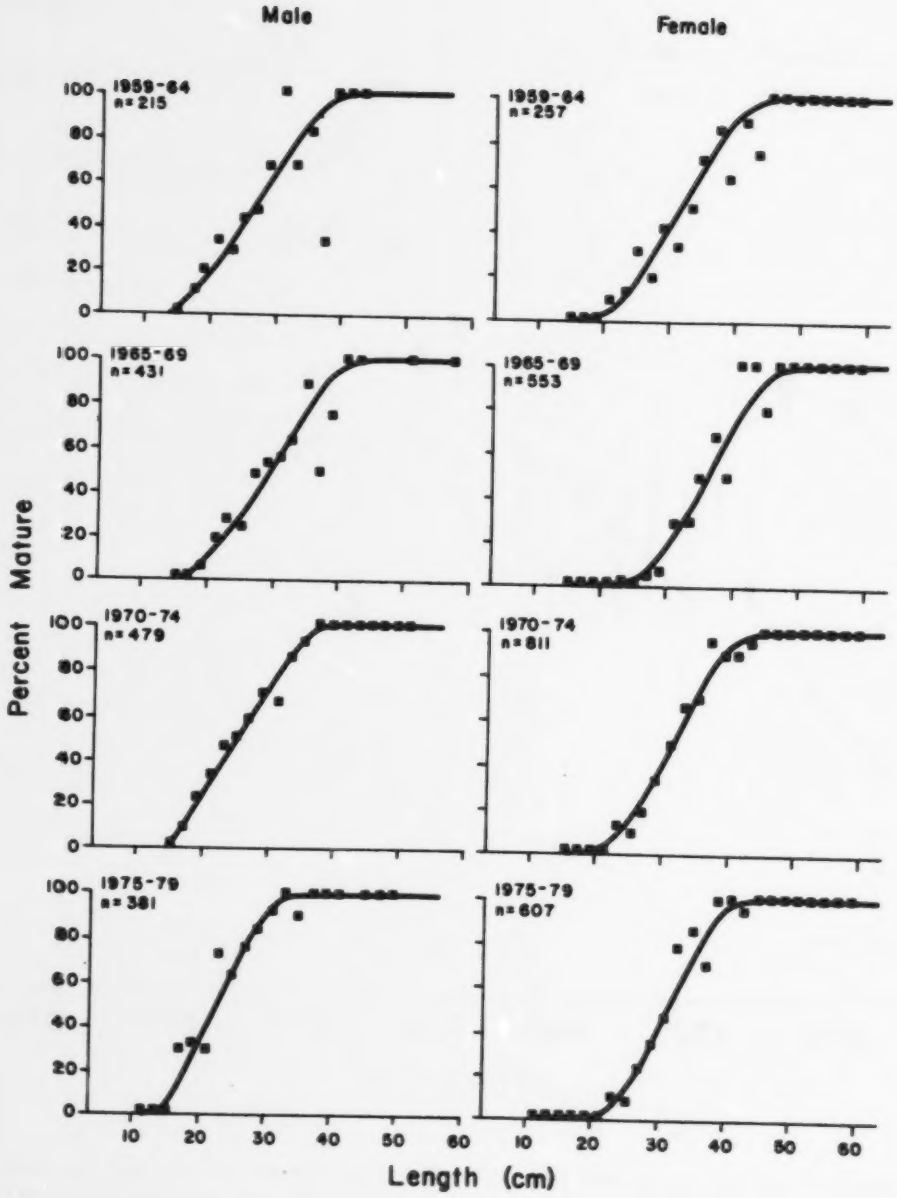

Fig. 16. Maturity ogives for American plaice caught during Canadian groundfish surveys in Div. 4X, 1959-1979.

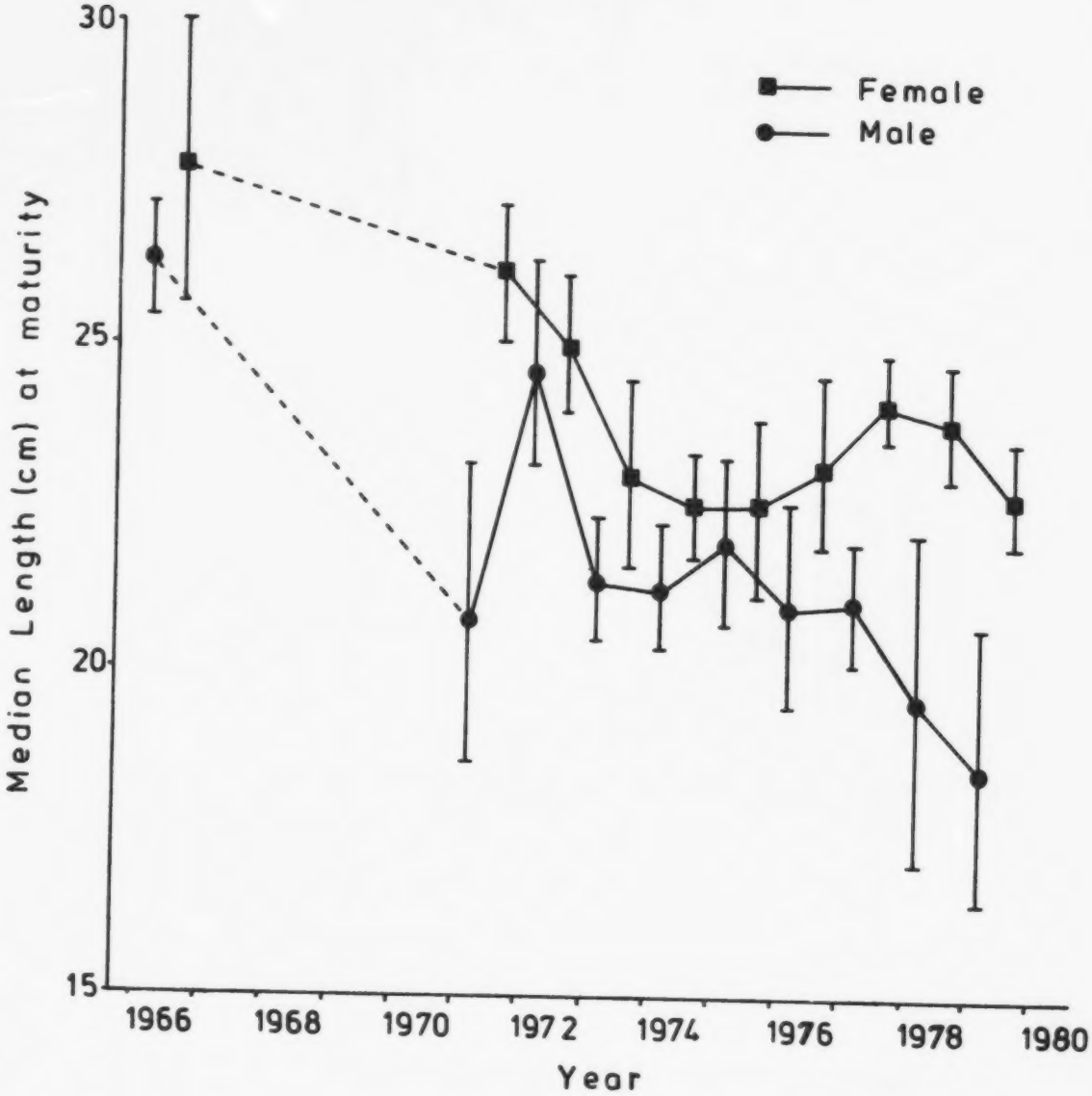

Fig. 17. Median length at sexual maturity for yellowtail flounder caught during September Canadian groundfish surveys in Div. 4T, 1966-1979. Vertical bars indicate 95% confidence limits.

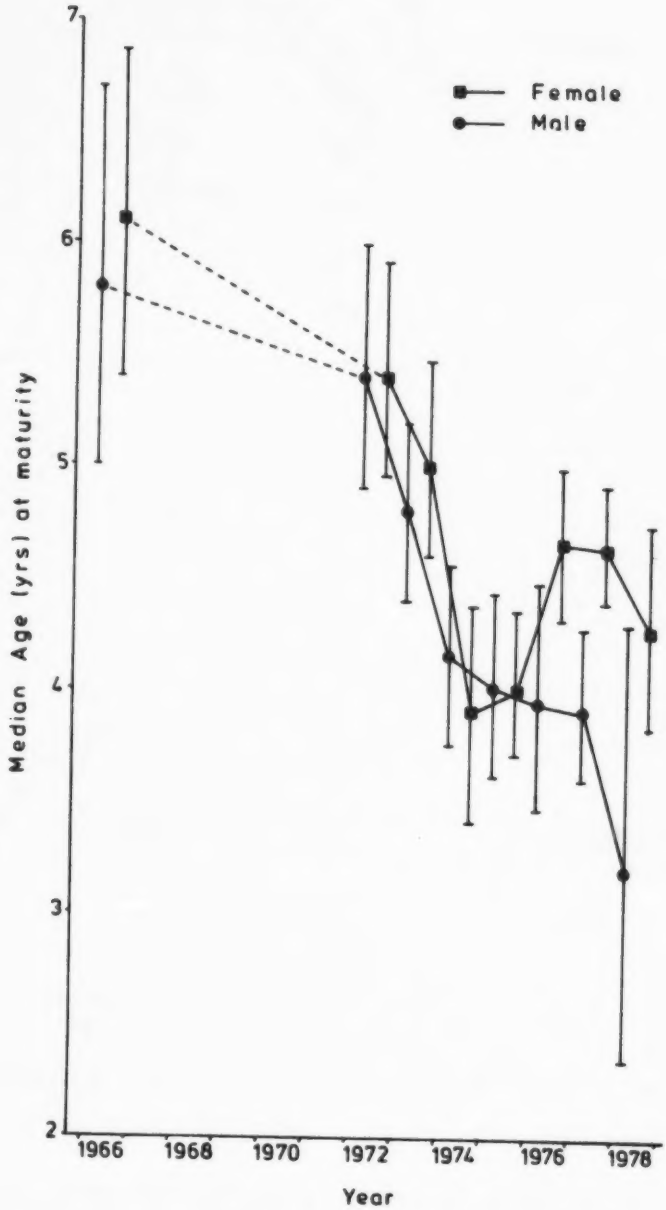

Fig. 18. Median age at sexual maturity for yellowtail flounder caught during September Canadian groundfish surveys in Div. 4T, 1966-1978. Vertical bars indicate 95% confidence limits.

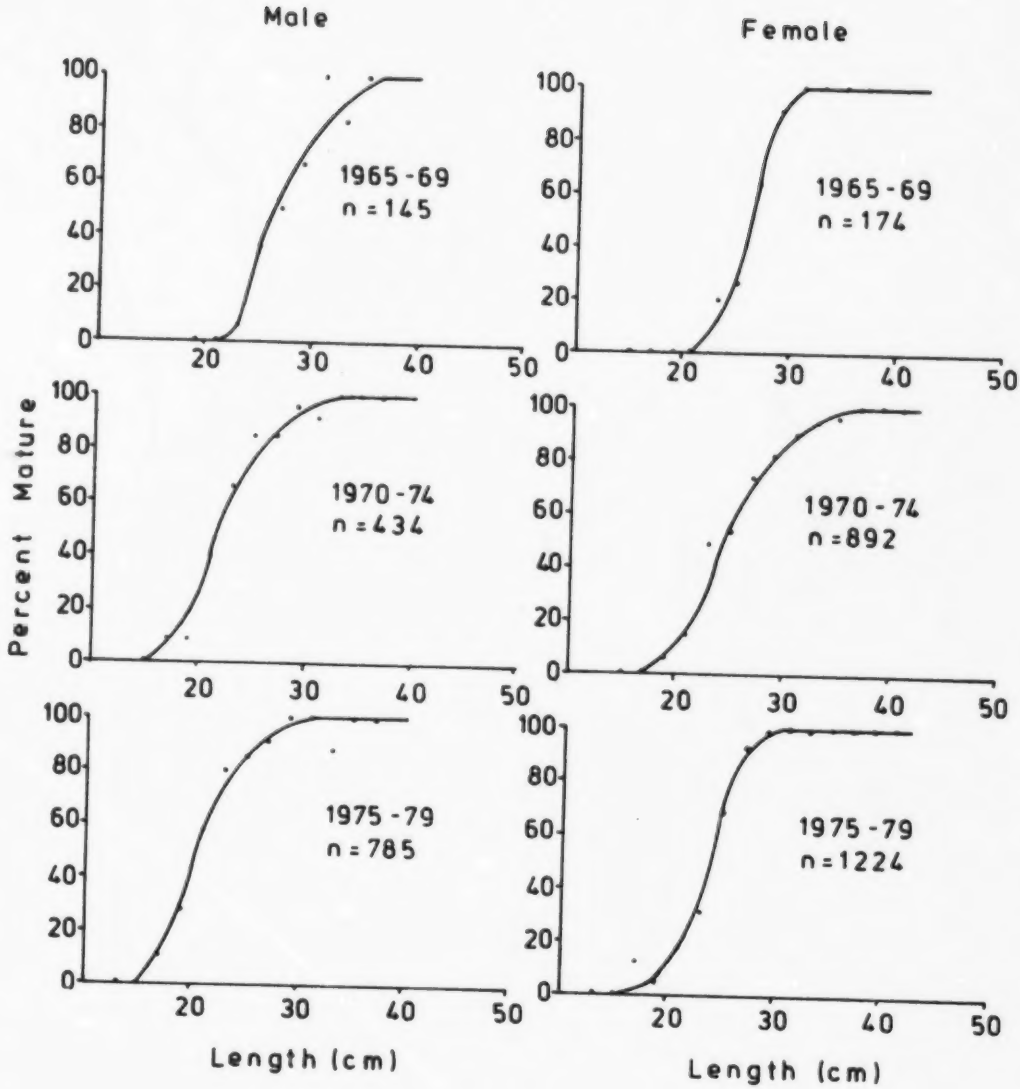

Fig. 19. Maturity ogives for yellowtail flounder caught during Canadian groundfish surveys in Div. 4T, 1965-1979.

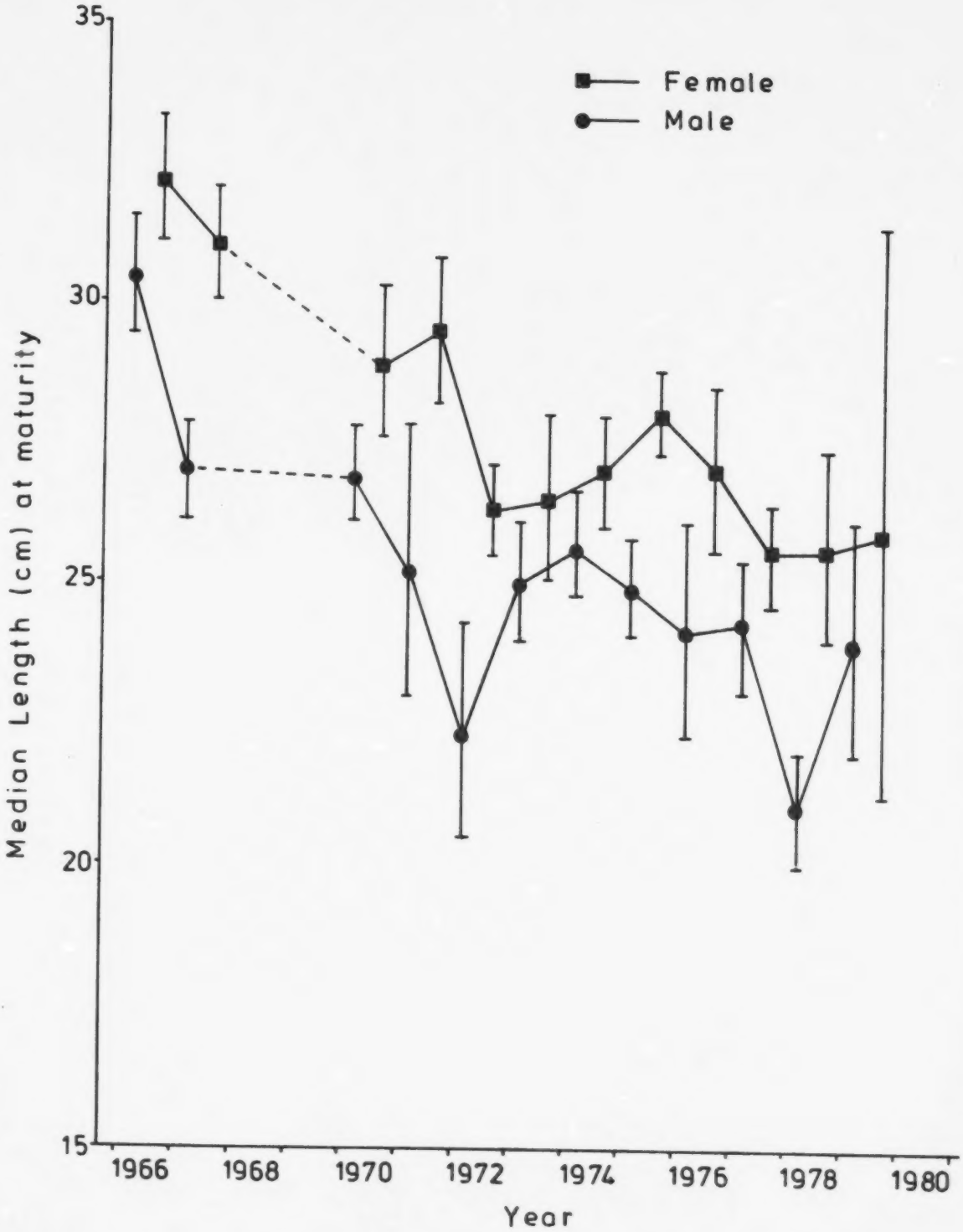

Fig. 20. Median length at sexual maturity for yellowtail flounder caught during Canadian groundfish surveys in Subdiv. 4Vs, 1966-79. Vertical bars indicate 95% confidence limits.

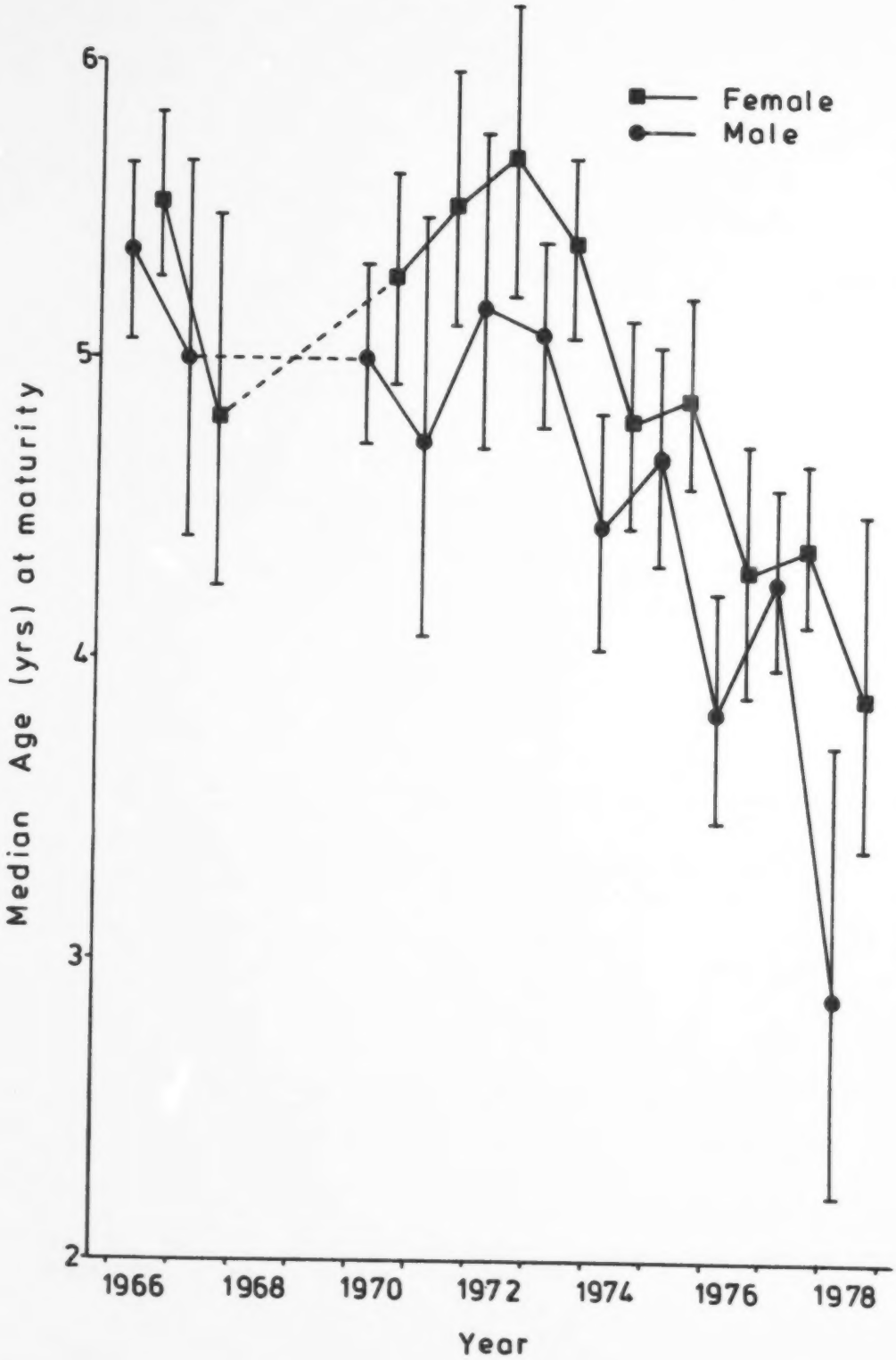

Fig. 21. Median age at sexual maturity for yellowtail flounder caught during Canadian groundfish surveys in Subdiv. 4Vs, 1966-78. Vertical bars indicate 95% confidence limits.

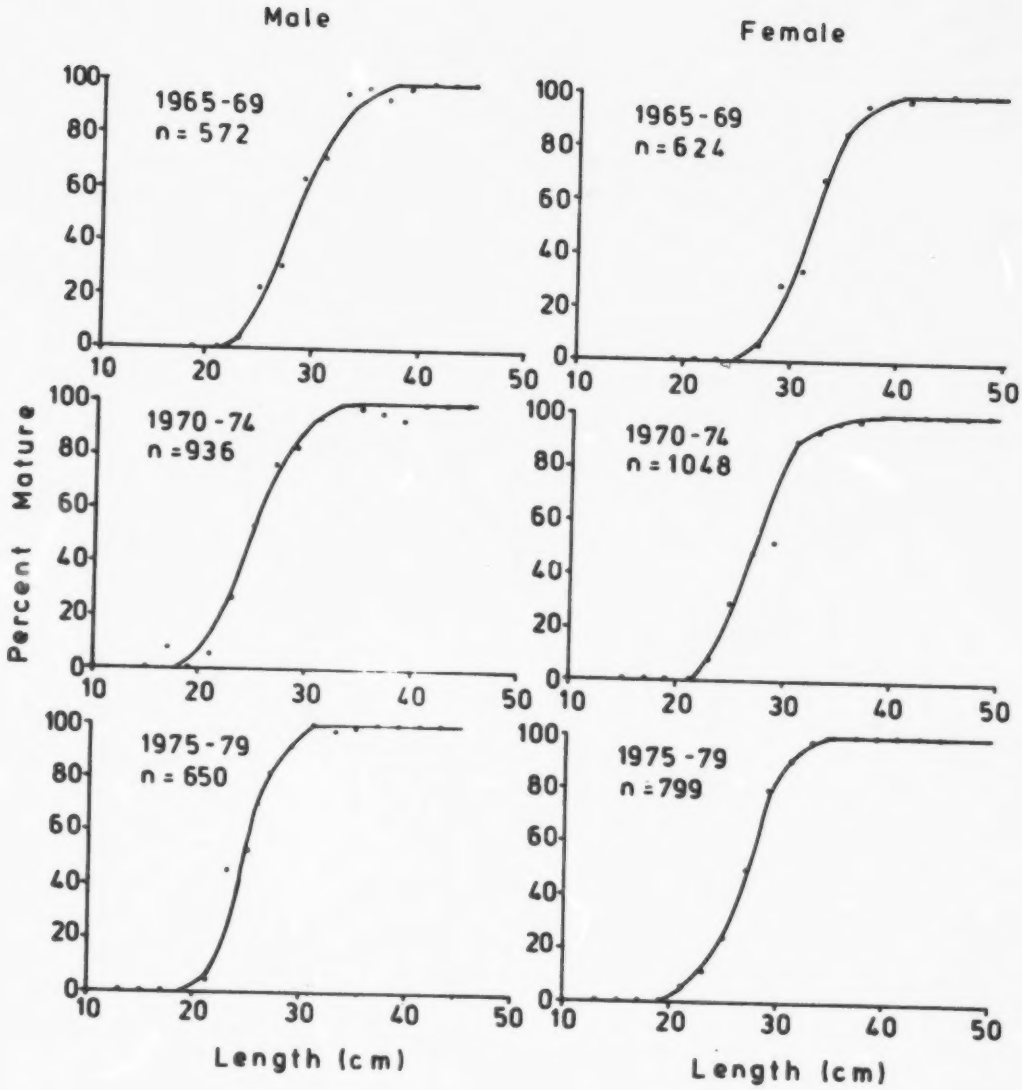

Fig. 22. Maturity ogives for yellowtail flounder caught during Canadian groundfish surveys in Subdiv. 4Vs, 1965-79.

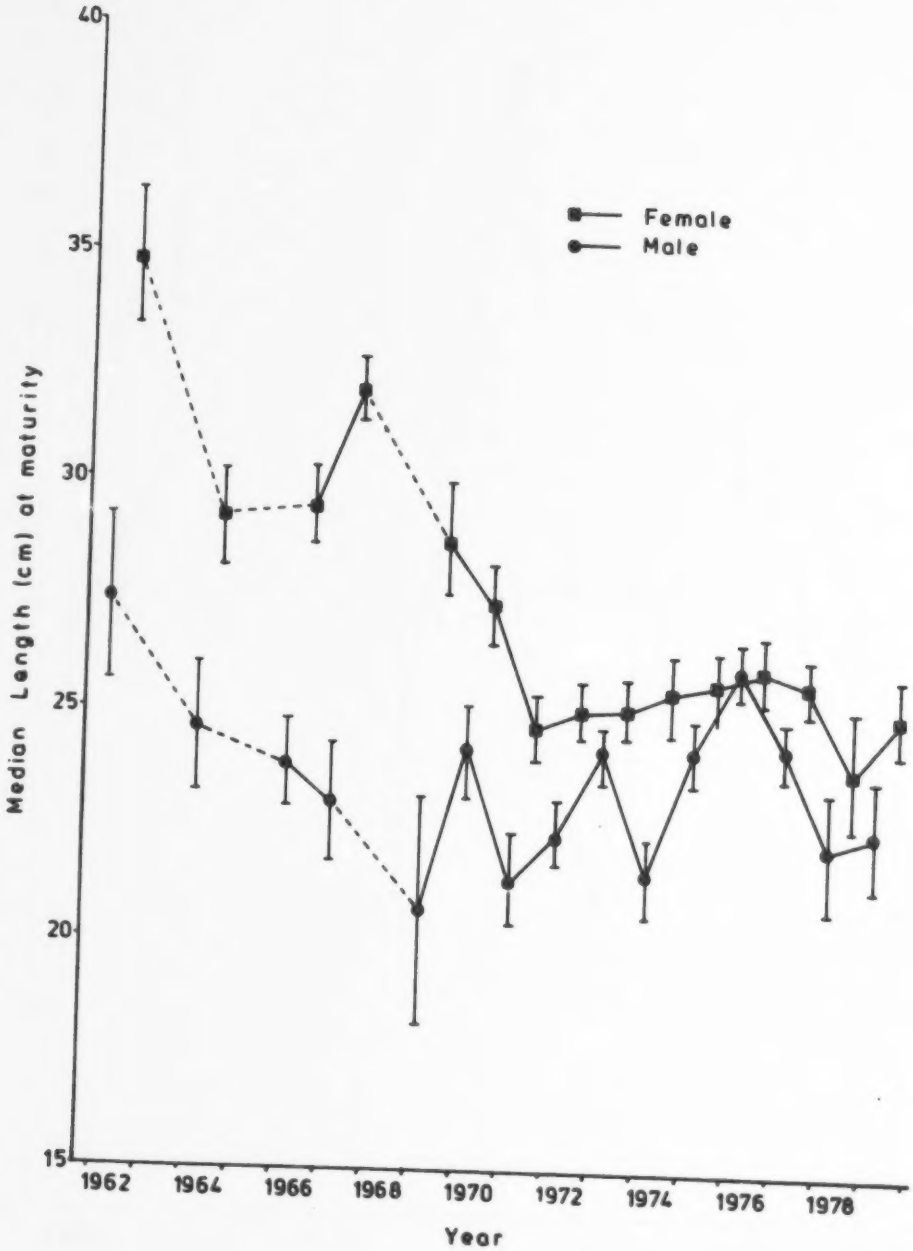

Fig. 23. Median length at sexual maturity for yellowtail flounder caught during Canadian groundfish surveys in Div. 4W, 1962-79. Vertical bars indicate 95% confidence limits.

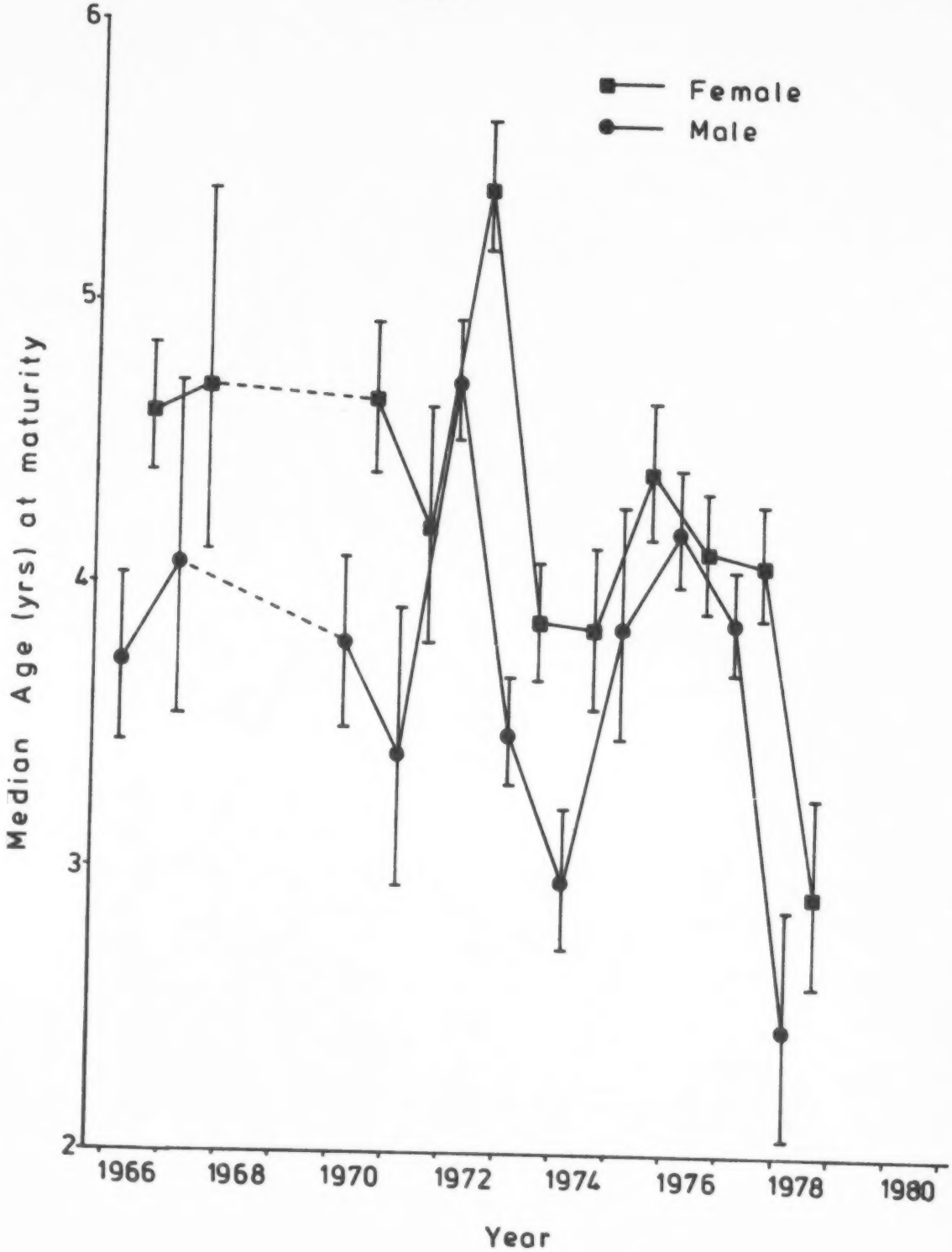

Fig. 24. Median age at sexual maturity for yellowtail flounder caught during Canadian groundfish surveys in Div. 4W, 1966-79. Vertical bars indicate 95% confidence limits.

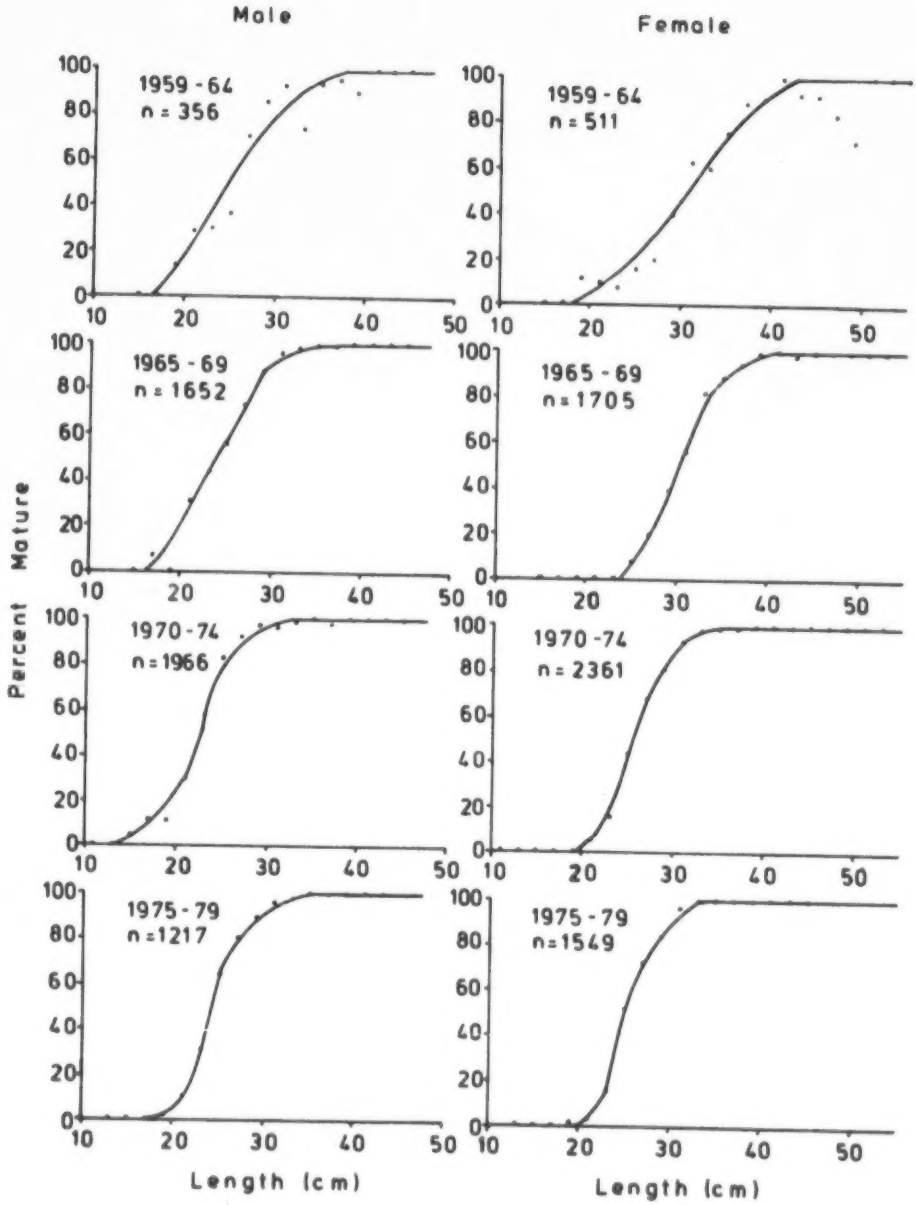

Fig. 25. Maturity ogives for yellowtail flounder caught during Canadian groundfish surveys in Div. 4W, 1959-79.

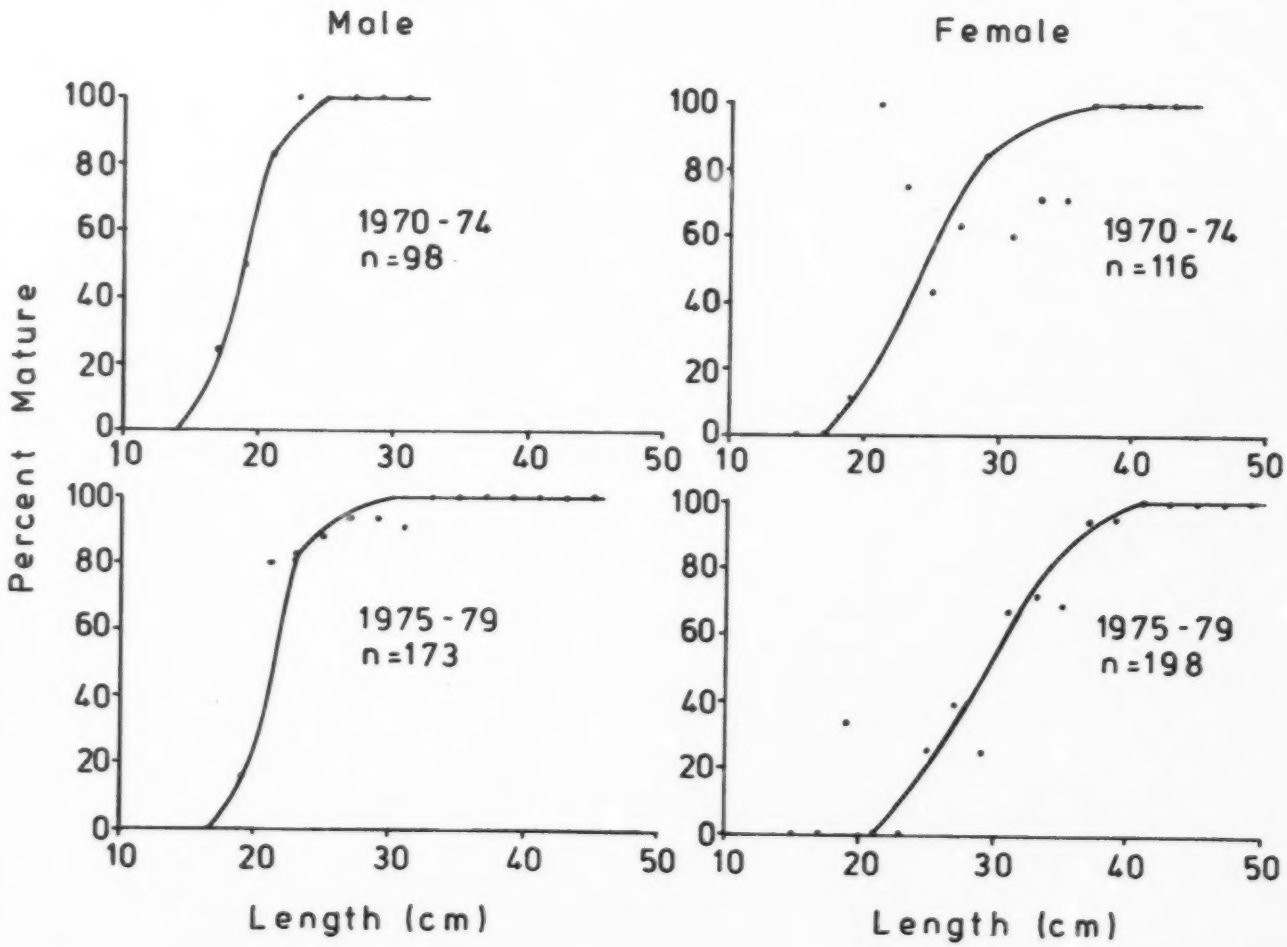

Fig. 26. Maturity ogives for yellowtail flounder caught during Canadian groundfish surveys in Div. 4X, 1970-1979.